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[OFFICIAL NOTICE.]

Twenty-sixth Annual Meeting of the New England Association of Gas Engineers.

OFFICE OF THE SECRETARY, December 26, 1895.

The twenty-sixth annual meeting of the New England Association of Gas Engineers will be held at Young's Hotel, Boston, on Wednesday and Thursday, February 19 and 20, 1896.

The meeting will be called to order at 10 A.M., Wednesday, February 19. A good list of papers on timely subjects has already been promised. The subjects and authors will be announced later.

The topics for discussion which proved of so much interest last year will be continued this year, and several gentlemen have arranged to speak on the subjects already selected.

The Question Box will be a feature as usual. Members will please forward their questions as early as possible.

The members will dine together on Wednesday evening.

Application blanks may be had of the Secretary. Applications for membership, and all other matters for the consideration of the Directors, should be sent to the Secretary before Tuesday evening, February 18.

C. F. PRICHARD, Secretary.

GAS ENGINES FOR ELECTRIC LICHT AND POWER.

Under the above caption we reprint elsewhere in this issue an article, by Mr. Nelson W. Perry, E.M., originally published in *Cassier's Magazine*. The author treats his subject very exhaustively, and gives some facts that will prove interesting to our readers. While his statements are in the main correct, we suggest that Mr. Perry rather allows his enthusiasm to get the better of his judgment in asserting that "When illuminating gas is burnt in a gas engine to drive a dynamo, much more light is produced if incandescent (electric) lamps are used than can be produced by burning the same quantity of gas in burners in the usual way."

Assuming that the gas engine uses 20 cubic feet per horse power hour, we get, by the usual basis of computation, ten 16-candle power incandescent lamps per horse power hour, or 160-candle power per 20 cubic feet of gas consumed per hour. With the ordinary open flame burner, consuming 5 cubic feet of 16-candle power gas per hour, we get but four lights, or 64-candle power with gas as against ten 16-candle power incandescent lamps, or 160 candle power with electricity. Thus far Mr. Perry's argument holds good; in fact, it would apply and show a balance in favor of his conclusions even with a 30-candle power gas burned with an ordinary open flame burner; but upon this basis only can his position be maintained. He certainly cannot have taken into consideration the vastly improved methods of burning gas that are now extant. There are a number of makes of high candle power gas burners, among them the Siemens-Lungren, where a consumption of 20 cubic feet of gas per hour would produce a light closely approximating 200-candle power, and the Welsbach incandescent lamp, where the results attained are very much greater. Twenty cubic feet of gas consumed by a Welsbach burner would yield 400-candle power, or, upon a basis of 3 cubic feet of gas per burner per hour, give 6⅔ lights of 60-candle power each, being the equivalent of 25 incandescent electric lights of 16-candle power each, requiring the consumption of 50 cubic feet of gas, if a gas engine is used for driving the dynamo.

We have figured that the percentage of deterioration in the light-giving properties of the incandescent electric lamp and the Welsbach incandescent gas lamp is about equal. The manufacturers of both styles of lamps claim a life of 600 burning hours for them. Experience has shown that this claim is about a fair average, but it must be remembered that, although the mantle employed in the Welsbach burner does not, after a time, give off the same luminosity as when first placed in the lamp, and consequently shows a decrease in candle power, the number of cubic feet of gas consumed per hour does not increase proportionately. In the incandescent electric lamp the conditions are different. Not only does the lamp decrease in candle power, but it requires considerably more current to supply it. This means a decided increase in the power exerted on the dynamo, and, if the motor used be a gas engine, calls for a corresponding increase in the number of cubic feet of gas used per horse power, and materially reduces the number of incandescent lamps derived from the original basis of computation.

We are rather amused at a statement made in another paragraph of Mr. Perry's article, in which he says, referring to the practicability of an electric light company getting its gas supply from a competing gas company, that, "Of course, nothing of this kind is practicable, for the

simple reason that no gas company is going to shoulder all the disagreeable features of its rival's business in order to enable the rival to compete with it." We hardly believe that, aside from the legal compulsion under which gas companies and other public corporations must meet the demands of applicants for their service, when such applications comply with the requirements of these corporations and are regularly made, any gas company would hesitate for one moment about supplying an electric light company with all the gas it wanted, provided there was evidence that the money to pay the bills would be promptly forthcoming.

MR. LITTLEHALES TO TAKE CHARGE AT SYRACUSE.

Last week we had occasion to say that Mr. Thomas Littlehales had voluntarily relinquished the dual position of Manager and Engineer to the Hamilton (Ontario) Gas Light Company, so that he might take up a permanent residence in the States. We might have gone a step further then and explained why it was that this important determination had been reached by Mr. Littlehales, since it may be taken for granted that the pleasant and successful business relations which existed for 23 consecutive years between the proprietors of the Hamilton Company and their Manager, would not be severed unless there were good and potent reasons for such severance. We may and do say now, however, that the new proprietors of the Syracuse (N. Y.) Gas Company made him an offer of the post of Resident Engineer on their works, and the terms, coupled with the preferment of the place, were sufficient to induce him to accept their proposition. Of course it is needless for us to say that we heartily welcome him to the States, and to New York, for such welcome must spring from our personal knowledge of the man and of his career, a knowledge that covers his progress with the gas industry since his earliest connection therewith. In Mr. Austin C. Wood, Mr. Littlehales succeeds, at Syracuse, a singularly competent and successful man, and we feel that we are not wide of the mark in writing it down that the works' administration of the present incumbent will be of the type that earned for his predecessor fame for himself and fortune for his employers. Mr. Littlehales' successor at Hamilton is Mr. Edmund Cathels, a son of the late Mr. E. S. Cathels. Mr. Cathels, if we mistake not, served his apprenticeship in the gas business under Mr. Littlehales, at Hamilton, and came to his new-old field from Butte, Montana, where he had charge of the Butte works. His appointment was made by the Hamilton Company on the suggestion and recommendation of Mr. Littlehales.

DEATH OF MR. LUCIUS B. DARLING.

We regret to report the death of Mr. Lucius B. Darling, who passed away, at his home on Walcott street, Pawtucket, R. I., on the evening of the 3d inst. Deceased was chosen to the Board of Directors of the Pawtucket Gas Company in 1867, and was elected President of the Company in 1880, continuing in that office up to the time of his death. He was born in Bellingham, Mass., October 3d, 1827, where his early years were passed upon the farm of his father. In 1847 he determined to abandon farming and went to Pawtucket where he engaged in the sale of meats. His venture prospered and he subsequently became interested in the manufacture of fertilizers, his initial attempt in that line being of a very modest nature. He persevered, however, and later on could look with complaisance upon the important operations of the L. B. Darling Fertilizer Works. Besides his connection with the Pawtucket Gas Company, to the affairs of which he devoted close attention, Mr. Darling was President of the Pacific National Bank, of Pawtucket. He was also prominent in the political life of his city and State, and served the latter as Lieutenant-Governor for two terms—1885-6. His wife and four children survive him.

NOTES.—The officers of the Consolidated Gas Company, of New Jersey, which concern controls the gas plants at Red Bank, Long Branch and Asbury Park, with franchises covering the right to supply gas in the intervening boroughs, are: President, Emerson McMillin; Vice-President, Paul A. Doty; Secretary and Treasurer, H. B. Wilson. We understand that the Company proposes to establish a uniform selling rate of $1.50 per 1,000.——The proprietors of the Atchison (Kas.) Company will shortly promulgate a rate of $1.25 per 1,000 for gas used for cooking, heating and power purposes.——The Councils of Philadelphia have appropriated the sum of $2,588,788 for the maintenance of the Bureau of Gas for the current year.——Mr. Robert Albertson has been chosen Secretary and Treasurer of the Equitable Company, of Chicago.——Mr. W. L. Jay has succeeded to the management of the works at Le Mars, Iowa.——Dr. Wm. G. Gray, of 2,810 Dayton street, St. Louis, Mo., had a tenant named Otto Sanders, whose apartments were on the floor over that occupied by the Doctor. There was gas in the house, but Sanders was not entitled to use it. The Doctor's gas bills having assumed undue proportions, he made an investigation which resulted in revealing the fact that Sanders had connected a gas stove with the gas pipes and was using gas for cooking purposes. He had told the Doctor that he cooked his food on an oil stove. He (Sanders) is to have an opportunity to explain the affair in court.

Gas Engines for Electric Light and Power.

[By MR. NELSON W. PERRY, E. M., in *Cassier's Magazine.*]

Taking coal as the starting point, the maximum theoretical efficiency of the steam engine is 30 per cent., while the maximum theoretical efficiency of the gas engine is 80 per cent. All mechanical devices fall short of theoretical possibilities, and while the steam engine, through the intermediary of the boiler, might possibly give us 30 per cent. of the primal energy of the fuel, and the gas engine 80 per cent., neither of them, even under the most favorable conditions, approaches these figures. The best that we can do under commercial conditions is to obtain in useful form, by means of the steam engine, about 10 per cent. of the energy of the coal, and with the gas engine, about 20 per cent.

The popular idea is that the price of fuel is controlling in the cost of power, but this is a fallacy that cannot be too rapidly dispelled for the best interests of the community. The cost of fuel, it is true, is an important item in the cost of power, and especially so where fuel is very dear, but it is often far less important than other items that are not usually considered by the layman, such as the interest on the original investment, depreciation, labor and others, and, above all, the relatively small proportion that we use of the total output of which the apparatus is capable. This is called the load factor.

If the apparatus be idle the interest charges go on. If the engines are working at less than their full capacity they are not doing justice to themselves, because the friction losses continue practically the same while the energy used is less. If, as often happens, it is necessary to throw out of use, for a few hours, a portion of the boiler plant, that portion is still costing something in the way of fuel, although contributing nothing to the income, and so and in other ways the 10 per cent. of the steam engine and the 20 per cent. of the gas engine are seldom realized in practice, while both are exceeded under test conditions.

The great problem of the day is how to work servants to the best advantage. The cheap cart horse probably covers more miles and does more useful work in a year than the high priced trotter, but the former requires more food than the latter. This one may, notwithstanding the greater investment charges, net its owner more than will the cart horse. Neither could succeed in the domain of the other, but the cart horse is by far the more useful animal.

The gas engine may be likened to the cart horse, though this homely, and to the gas engine, seemingly uncomplimentary simile is a very imperfect one. Some of the advantages of the gas using engine are:

1. It is, as made to day, even in sizes as small as 10 horse power, quite as efficient as the largest compound condensing steam engine.

2. It may be started at a moment's notice and stopped as quickly, consuming no energy while shut down.

3. There are no water gauges nor safety valves to watch.

4. In the case of gasoline and oil engines, there are no ashes to carry away, no chimney is required, nor, in the case of small sizes, is the skill required to properly operate them by any means so high as that necessary with the steam engine.

5. In the larger sizes of gas engines, where the consumption of gas is so large as to make it more economical to manufacture than to buy one's own gas, a gas generating apparatus is, in all respects, the equivalent of the boiler plant. The cost to install this is about the same or less per horse power as the cost for the cheaper types of boilers. It is considerably less than for water tube boilers, the attendance is about the same or less, and the depreciation charges are far less than with steam boilers of any kind. This is a most important point.

The standby losses of a gas plant as compared with those of a boiler plant are about as 2 is to 10. Another point of vital importance is that the gas plant requires no chimney, so that in this economy there is another important item in the way of lessened original investment and consequently lessened fixed charges.

In case a small gasholder is used, the space required is no greater than with a steam plant, but the gasholder constitutes the cheapest and most efficient means of storage of energy known. It is this resource alone that enables gas lighting to exist as a commercial industry, and it will probably pay to make the holder a little larger so that this

method of storage of energy may be available. By this means the standby losses of the gas generating plant may be entirely removed.

With steam, the only possible equivalent is the thermal storage of Druitt Halpin, which the author described in a paper before the National Electric Light Association of the United States a little less than a year ago. Halpin's method has a very considerable advantage over gas storage as regards space, requiring but 6.4 cubic feet per effective horse power hour storage, while illuminating gas requires about 20 cubic feet; but gas has at least equal advantage in the way of cost and other respects that will be referred to later.

In the way of fuel the gas plant has the advantage in every way. With improved grate bars we are now successfully using such utterly waste products as the refuse from culm piles in the coal fields, but in the gas plant we can use this to still better advantage. By converting it into a fuel gas we have a prepared fuel of a very high order, superior in many ways to the very finest grades of steam coal anywhere to be found, and the same can be said of other refuse matters utterly incapable of being used under boilers.

Even with the best of fuels the gas plant still has the advantage, for by its use 80 per cent. of the fuel is converted into gas and is brought to the engine, while it is scarcely possible to bring 70 per cent. of the heat which coal should generate to the boiler. By no means all of this is utilized in either case, but a far greater proportion can be utilized in the gas engine than in the steam engine. This is the reason, or chief reason, of the truth of the statement made at the opening of this article, that "the maximum theoretical efficiency of the gas engine is 80 per cent., and that of the steam engine 30 per cent."

Sir Frederick Bramwell, at the Jubilee meeting of the British Association in 1881, made a prophecy which is likely to be fulfilled—all except the museum part of it—much earlier than the date set. He said that in 1931 engineers would look at steam engines of small size as articles of antiquarian interest, and that they would be put in museums, being out of use altogether, and superseded by internally fired engines.

It was Dr. John Hopkinson who first drew attention to the fact that when illuminating gas is burnt in a gas engine to drive a dynamo, much more light is produced if incandescent lamps are used than can be produced by burning the same quantity of gas in burners in the usual way. Such a statement seems anomalous, but it is not only true that more light can thus be gotten, but that one can buy city gas at ordinary rates, burn it in a gas engine and light his house with electricity more cheaply than he can with that same gas direct or with electricity bought from any of the electric light companies at their usual meter rates. This the writer found, by tests, was actually being done in several places.

If the private consumer can do this after having paid a profit for his gas to the gas company and for the cost of delivery, the question arises, Why cannot an electric light company do the same? If city gas were used to drive the dynamos of a central station, the consumption would be 50 per cent. less than the volume required to give the same number of lights as the dynamos thus driven could furnish at the station. In other words, if a central station drove its dynamos with city gas, those dynamos would supply just twice as many lights as the gas thus used could supply directly in gas burners.

The electric light station could throw away or sell its boilers and engines and devote the boiler plant space to other uses. There would be no expense for firemen, nor for the removal of ashes. Coal would not have to be handled, and the saving in coal bills and in the space necessary for coal storage would lessen the gas bills by so much. Furthermore, there would be no standby losses as at present, and instead of keeping up steam in order to meet any sudden fluctuation in the load, the standby would be the gas main, requiring only to be tapped to supply any demand.

Of course, nothing of this kind is practicable, for the simple reason that no gas company is going to shoulder all the disagreeable features of its rival's business in order to enable the rival to compete with it. But as a simple proposition there is no question that if a lighting station could buy its fuel from the gas company it could pay the latter its usual rates and still beat it on the ledger.

Would it pay, then, for an electric lighting company to establish an illuminating gas plant for its own supply? Probably not, for the reason that, unless everything were on a very large scale, the economies in space and labor above referred to would not only disappear, but, instead of economies, greater charges on these accounts than before existed would undoubtedly result.

Another question here suggests itself. Supposing a single corporation owned a number of large lighting stations, distributed in different portions of a city, having enough customers to make, if these customers used gas, a gas plant a paying investment, would it pay that corporation to erect a central gas plant, and from this distribute illuminating gas solely to its various stations for use with gas engines, assuming also the right of way for its pipes could be obtained? I think it would.

In the first place, it has been found profitable in many places to distribute electricity at high potentials from a central lighting station to a number of sub-stations, for the purpose of charging accumulators at those sub-stations. But it is cheaper to transmit gas than it is to transmit electricity on low potential circuits. Mr. Denny Lane,[1] an English engineer of prominence, says that, with ordinary 16-candle power gas, 3,000 horse power could be sent a distance of one mile for an expenditure of one horse power—an economy of distribution far exceeding that possessed by any other system, being only 1-30th per cent. of the power conveyed.

With respect to the cost of mains, taking the cost of conductors laid on the low-pressure culvert system at $27,500 per mile for the conveyance of 1,080 amperes, and assuming an electro motive force of 110 volts, the power would be 158 horse power. It would therefore require, he says, two pairs of these conductors to convey 300 horse power, whilst a 6-inch main, with ordinary gas, would convey sufficient gas for that power at 4 inches pressure, and at 16 inches pressure would deliver as much as four pairs of such conductors. The 6-inch main, he says further, would cost $2,500 per mile, while two pairs of low-pressure conductors would cost $55,000, and four pairs would involve an expenditure of $110,000 per mile.

The writer has found, by calculation, that to transmit this power to the distance named at 220 volts, the metal in the pipes would cost considerably less than the metal in the conductors. Contrast this with electrical transmission, in which 10 per cent., or 300 horse power, would be an allowable loss, and we see how the gas transmission has the advantage over the electrical.

The ideal location for an electric light plant is in the center of the district to be supplied. It is not often that such a location is favorably located as regards fuel, and the latter has to be carted from the railroad, which involves a double handling and an additional charge on the fuel. In such a location real estate is apt to be high, and economy of space, therefore, becomes particularly desirable, not only to save taxes, but to reduce the investment account, so that the interest charges may be reduced to a minimum.

Could we abolish the boiler from such a location, the saving in real estate would be about two-thirds. If we employed gas, the gas plant might be placed on the railroad or at tidewater, where land was cheap and where fuel could be delivered at a minimum cost. The gas generated there could be transmitted with insignificant loss to the lighting station where the gas engines and dynamos, arranged upon a minimum of real estate, but upon the several floors of a building, would work under conditions of fixed charges far more favorable than usually exist. Further than this, an inferior and therefore a cheaper grade of fuel would be permissible.

Thus far we have, in speaking of gas, referred to illuminating gas. But the near future is to see the general introduction of a cheaper grade of gas, intended solely for fuel purposes. This fuel gas, already largely used in some metallurgical operations, and in isolated plants with gas engines, is essentially a water gas, but of lower grade than that produced in illuminating gas establishments, and is still further cheapened by the omission of some of the cleansing processes necessary in the latter. Its specific gravity is 0.87 to 0.88, and its calorific power, as compared with 16-candle power illuminating gas, is about one-fourth. The cost to produce it in England is between 4 cents and 6 cents per 1,000 cubic feet.

The process of manufacture is exceedingly simple, and consists in forcing steam and air into a sealed ashpit, above which is an anthracite or coke fire. From the generator the gas passes first through a cooler, then through a coke scrubber, and then through a sawdust scrubber, whence it passes to the gasholder. One ton of fair anthracite coal will produce from 150,000 to 160,000 cubic feet of this gas, and in its use the following economies are usual:

At Chelsea, England, Messrs. Mead & Son have a 60-horse power (nominal) Crossley gas engine with twin cylinders, employed in driving a flour mill. While the engine was still new (3 months' service), a trial, lasting 8 hours, was made by Mr. Dowson with the mill work going on in the usual way. This test was confirmed by a second day's run, and gave the following results:

1. Mr. Lane, who had been for many years Secretary of the Cork (Ireland) Gas Company died Nov. 29, 1895.—Ed. A. G. L. J.

	Left Cylinder.	Right Cylinder.	Both Cylinders.
Mean pressures of indicator diagrams in lbs. per sq. in	79.9	77.9	78.9
Average I. H. P. during trial, with speed of about 156 revolutions per minute	59.3	59.4	118.7
Maximum I. H. P. with full speed of 160 revolutions	...	...	173.6
Anthracite consumed in the generator during trial	0.615 lb. per I. H. P. per hour.		
Coke consumed in boiler during trial	0.147 " " "		
Total during trial	0.762 lb. per I. H. P. per hour.		
Anthracite put in the generator on the morning after trial, to make up for loss during nine night hours, 56 lbs.	0.058 lb. per I. H. P. per hour.		
Ditto to make up for loss when raking out clinkers, etc., 50 lbs	0.053 " " "		
Total loss during the night, and after clinkering on the following morning, 106 lbs	0.111 " " "		
Water for cooling the engine	5 gallons " "		
Water for boiler of gas plant	½ pint " "		
Water for washing gas, etc	1 pint " "		

It will be noticed that the standby losses of the gas generator were exceedingly small in this case. As this question is one of considerable importance, it may be worth while to recount some other experiments in which these losses were very carefully determined.

In discussing a paper by Mr. Dowson on "Gas Power for Electric Lighting," read before the British Institution of Civil Engineers in 1893, Mr. Dowson said that in order the better to determine these losses he had resorted to the expedient of placing the generator on a weighing machine. The gas was taken to an engine under trial, and by having a hydraulic joint, perfectly free in the pipe leading from the generator, gas was made continuously, while, at the same time, it was possible to tell at any time what was the actual weight of fuel converted into gas. The generator was worked with anthracite, and served about 32 brake horse power. After the trial, the generator was left on the weighing machine, with a fire in it, but without draught, for 18 hours, in the month of November, and during that time the waste of coal was 18 pounds.

On another occasion, a generator of about the same size had been worked in a similar way with coke, and, after the trial, was left on the weighing machine in the open air, in November, for 17 hours. During that time the waste of coke was 60 pounds, or about 3½ pounds per hour. On still another occasion, at Chelsea, a generator served about 150 indicated horse power, and three tests had shown that the waste of anthracite during the time of standing was from 6 to 8 pounds per hour. At Openshaw a still larger generator worked with anthracite,

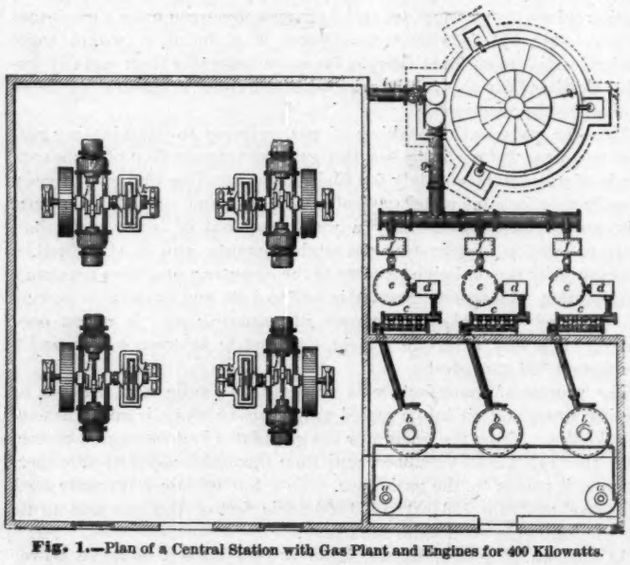


Fig. 1.—Plan of a Central Station with Gas Plant and Engines for 400 Kilowatts.

and serving between 250 and 300 indicated horse power, was worked under the following conditions:

On the 19th inst., the working of the generator was stopped at 8 P.M., and started again at 5 A.M. the next day. The waste during these nine hours was 69 pounds, or 7.6 pounds per hour. On the 20th inst. the generator was stopped at 8 P.M. and started again at 5 A.M. the next day, the waste being 5.1 pounds per hour. On the 21st inst. the generator was stopped at 2 P.M. and started again at 7 A.M. on the 23d inst., an interval of 41 hours, the waste being 3.9 pounds per hour.

It is very evident from these figures that the standby losses of a gas generator are almost negligible as compared with what would occur with steam boilers, and that thus one of the greatest sources of fuel loss in the central station may be obviated. Just what the standby losses of steam boilers are it is difficult to state with any degree of accuracy, but Prof. Kennedy and Mr. Crompton both estimate it at about 10

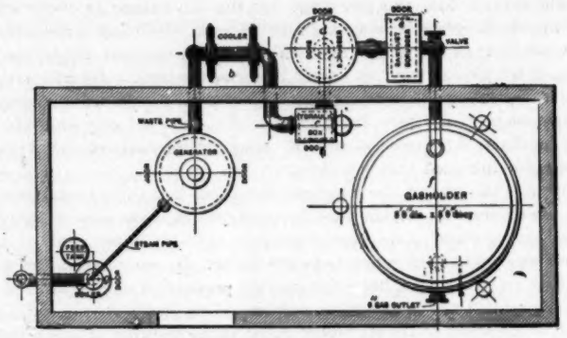


Fig. 2.—Plan of a 100-Horse Power Dowson Gas Generator Plant.

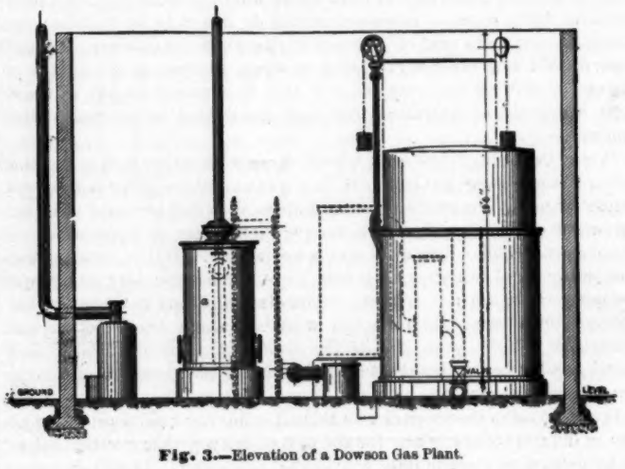


Fig. 3.—Elevation of a Dowson Gas Plant.

per cent. of the total consumption in all the boilers, or, for every 1,000 tons utilized, 100 would be charged to standby losses.

Let us next take up the gas engine. The losses between a gas generator and engine will be less than between a boiler and steam engine, first, because in the former there is no condensation, and second, because the gas being under, at most, 1 or 2 inches of water pressure, the leakage due to defective joints would be small, whereas with steam under high pressure it might be large.

As regards the mechanical efficiency of the gas engine, Mr. Bryan Donkin, in his "Gas, Oil and Air Engines," tabulates the results of a very large number of tests with engines of different makes and sizes, which show efficiencies varying between 55 and 91 per cent. Most of these were very small engines, less than 10-horse power, and some as small as 1-horse power, the largest, except one, being 27.75 brake horse power, which gave 82 per cent. The one exception was working at 92.5 brake horse power, and gave an efficiency of 72 per cent. These figures seem low, but will compare favorably, except in the last instances, with efficiencies obtained from similar sized steam engines.

It has been argued that the use of gas engines necessarily involves the use of small electrical units. This is not strictly true, however, since it is customary, where larger units are desired, to couple up two or more engines to one generator. By so arranging these engines as to have their explosions alternate with each other in the case of a pair, or to succeed one another in case of a larger number, a positive advantage may result in the way of greater regularity of speed. While, so far as the writer knows, the largest single gas engine thus far built is of a capacity of 375-horse power, compound gas engines of considerably greater capacity have already been built, and it is understood that the

leading English manufacturers stand ready to fill orders for compound engines up to 1,000-horse power if desired.

The demand for the larger sizes of steam engines is chiefly due to the fact that in them greater efficiencies are attained than with smaller ones. This is not true with gas engines, however—at least not to the same extent. With dynamos, after a certain size is reached, no further increase in efficiency is possible by still further increasing the size, so that the reason for large units does not exist in the dynamo. With varying load lines, such as we have in lighting stations, large units are, in one sense, a positive disadvantage, in that they can meet the variations less efficiently than could smaller ones. With the gas engine, therefore, in which, in the smaller (as compared with steam engines) sizes, equally high efficiencies are attainable, and where, when shut down, the consumption of fuel absolutely ceases, the reason for large units, to a certain extent, disappears.

For an electric plant of 400 kilowatts, Mr. Dowson[1] recommended the arrangement shown in Fig. 1. In this there are three generators, each capable of supplying one-third of the maximum power. Each generator has its own cooler, hydraulic box and scrubbers, so that they can be worked together or singly.

The cost of this plant, including erection, foundations and ashpits for generators, is given at $5,500, or about $10 per horse power for the gas plant. If this were all on one level it would occupy a ground area of about 27 feet by 54 feet; but, if necessary, he states that all, except the gasholder, can be placed under or over the engine room.

Figs. 2 and 3 are a plan and an elevation of a Dowson gas generating plant of 100 horse power kindly prepared for the writer by Mr. Dowson himself. This shows, in detail, the arrangement of the various parts making up a single unit of 100 horse power. A larger plant would consist simply in a multiplication of such units as are shown in plan in Fig. 1.

Mr. Thwaite in England has suggested the conversion of coal at the coal mines into fuel gas, and the utilization of this gas in gas engines for the production of electricity, to be transmitted to neighboring towns for light and power purposes. In the anthracite coal regions in the United States there are vast accumulations of culm, of which the fuel value is already attracting attention. As burned under the boilers, there is much waste—sometimes as much as 30 to 40 per cent. of the fuel being found unburnt in the ashpit. A much more rational procedure would be to convert this into a first-class and manageable fuel in the form of fuel gas, and then burn it in gas engines for electrical and other purposes.

If this culm could be laid down on the water front in New York or Philadelphia, as has been claimed, at $1.85 per long ton, and there converted into fuel gas, it would be possible, if the right of way could be procured, to pipe it to every electric light station in either city, where, if gas engines were employed, it could be directly converted into electricity at a cost far less than at present attends the production of electrical energy.

It may be too soon to expect such revolutionary methods, and probably it is; but metallurgists have long realized that the ideal fuel is a gaseous one, and are awaiting its coming into general use with some impatience. The advent of natural gas has educated the public to its use, and the appliances for its proper utilization are all existent. It remains only for some enterprising individuals to start a fuel gas plant for public supply, just as illuminating gas plants exist for gas lighting supply. When such an organization comes into existence, the public will be the gainers, and among that public none will be a larger beneficiary than the electric light manufacturer.

The History of Argon and Helium.

By Alfred R. L. Dohme, Ph.D.[2]

Toward the close of the year 1894 Lord Rayleigh, Professor of Physics at the University of Cambridge, and Secretary of the Royal Society of London, published a paper[3] in the Proceedings of the Royal Society, in which he described some anomalies encountered in determinations of the density of nitrogen gas. Lord Rayleigh communicated his curious experiences to Prof. Willam Ramsay, Professor of Chemistry, University College, London, and together they undertook to solve the intricate and intensely interesting problem. On January 31, 1895, they read a paper before the Royal Society, entitled, "Argon, a New Constituent of the Atmosphere," and the result was that the scientific world in particular, as well as the world in general, were set on edge, unbalanced as it were, and neither have yet fully recovered their equilibrium. To think that for more than a century people had been daily breathing, handling, testing, analyzing and discussing the all-pervading atmosphere of our planet, and had not, until the year 1894, discovered that it contained something besides oxygen, nitrogen, carbon dioxide, water vapor and nitrous acid was touching that world in a very tender spot, and it felt hurt. Facts are facts, however, and never respect feelings. We may very properly consider the discovery of these English scientists as epoch-making, because, as we shall see, they introduce into the science of chemistry something that is entirely new to it. Lord Rayleigh had found that nitrogen extracted from chemical compounds is about 0.5 per cent. lighter than atmospheric nitrogen. With Professor Ramsay he then made nitrogen in six different ways, and determined the density of each kind of nitrogen. Let us, for convenience, call this nitrogen obtained from chemical substances, "chemical nitrogen" to distinguish it from "atmospheric nitrogen," as this term had been understood prior to the autumn of 1894.

The chemical nitrogen was obtained:

(1) From nitrous oxide, and gave a density of	2.2990
(2) From nitric oxide, and gave a density of	2.3001
(3) From ammonium nitrite purified at a red heat, and gave a density of	2.2987
(4) From ammonium nitrite purified in the cold, and gave a density of	2.2987
(5) From urea by means of sodium hypobromite, and gave a density of	2.2985
(6) From air by means of hot magnesium and subsequent liberation as ammonia and conversion into nitrogen by means of calcium hypochlorite, and gave a density of	2.29918

The mean of all these densities is 2.2990, which is hence the density of chemical nitrogen, while, as a mean of three experiments, the density of atmospheric nitrogen was found to be 2.3102.

The difference was naturally at first attributed to impurities, but none such in form of a lighter gas could be found in the chemical nitrogen. The next explanation was that some of the nitrogen molecules of the chemical nitrogen had been split up into atoms. Both kinds of nitrogen were then tested in this particular by subjecting them to the silent electrical discharge, and both were found to retain their volume unaltered, thus dispelling the possibility of this explanation. There remained, then, only as the explanation of the discrepancy in weight, the fact that one of the gases was a mixture of several gases. To assume that chemical nitrogen was a mixture was contrary to experience and to Stas' work. Hence the hypothesis was made that atmospheric nitrogen contains something else than nitrogen. The identification of "phlogisticated air" with the constituent of nitric acid is due to Cavendish, whose method consisted in operating with electric sparks upon a short column of gas confined with potash over mercury at the upper end of an inverted U tube[1]. The repetition of Cavendish's experiments only served to increase the admiration with which this great investigator is generally regarded. Cavendish, after repeatedly sparking this "phlogisticated air," *i. e.*, nitrogen with oxygen, found that some always remained that could not be converted into nitric acid, and that it constituted about $\frac{1}{120}$ part of the whole. Whether he regarded this gas as an impurity or as nitrogen cannot be determined, but it is more than likely that what he had in the top of his inverted U tube was what we now call argon. Cavendish's experiments were repeated, and it was found that the amount of his unsparkable gas was proportional to the amount of air operated upon. A sufficient quantity was made to determine its spectrum, and it was found that it did not give the spectrum of nitrogen, but of argon. Next, Rayleigh and Ramsay made argon in quantity from air by removing, one after the other, constituents of the latter; thus moisture by means of phosphorus pentoxide, oxygen by means of sparking with hydrogen, carbon dioxide and nitrous acid by means of caustic alkalies, and, finally, nitrogen by means of red hot magnesium and magnesium vapor. This is a very tedious operation, especially the removing of the last traces of nitrogen. They then proved that chemical nitrogen does not contain more than traces of argon, by treating a large quantity of the former in the same way as they had treated the air. They invariably found argon present, but only to a small fraction of the extent it would have been there if atmospheric nitrogen had been used. Thus, where they

1. "Gas Power for Electric Lighting," by J. Emerson Dowson, in a paper read before the British Institution of Civil Engineers, January, 1893.

2. From *Journal of Pharmacy*.

3. Rayleigh, "On the anomaly encountered in determinations of the density of nitrogen gas." Proc. Roy. Soc., 55, 340 (1894).

1 Cavendish—Experiments on Air; Phil. Trans., 75, 372 (1785).

would have obtained 30 cc. of argon if atmospheric nitrogen had been used, they actually only found 3.3 cc. of argon. This had, of course, been introduced from the air and the water used, and to their minds proves that chemical nitrogen does not contain argon.

Properties of Argon.—The density of argon made by the Cavendish oxygen method was found to be 19.70, H_2, or the hydrogen molecule, being taken as 1; while that of argon made by means of magnesium was found to be 18.90. The spectrum in wave lengths is:

Blue line, wave length	487.91	Strong.
" " " "	476.50	Fairly strong, characteristic triplet of lines.
" " " "	473.53	
" " " "	472.56	
Red line, " "	696,56	Strong.
" " " "	705.64	"
Yellow line, wave length	603.84	"
Green line, " "	561.00	"
And four other green lines.		
Blue-violet line, wave length	470.2	"
Violet line, " "	420.0	"
And five other violet lines, all strong.		

Professor Crookes, who is studying the spectrum of argon, has concluded that this gas possesses, most likely two spectra, which he thinks he can separate. This would indicate that argon is a mixture of two gases. Argon is about 2½ times as soluble in water as nitrogen, and possesses, approximately, the same solubility in water as oxygen. We hence find, as we would expect as a result of these determinations, that rain water contains more argon than nitrogen.

Professor Olszewski, of Cracow, has liquefied argon, and also solidified it by the combined action of extremely high pressure and low temperature upon it. He obtained it in white crystals which melt at —189.6° C. Its critical temperature is —121° C., and its boiling point is —187° C., both of which are lower than the respective constants of oxygen.

By determining the velocity of sound in a gas, we can determine the ratio of the specific heat at constant pressure to that at constant volume. In the case of argon, this ratio was found to be 1.66, which is proper for a gas in which all the energy is translational, *i. e.*, to a gas that is monatomic in its condition. The only other such known gas is that of mercury at high temperatures.

All attempts to induce argon to combine with other elements have proven abortive, and the gas has well earned its name of "no energy" from the Greek words *a* and ἔργον, contracted into ἄργον. The amount of argon in the air is, approximately, 1 per cent.

From Avogadro's law we know that the density of a gas is half its molecular weight; and as the density of argon is, approximately, 20, its molecular weight must be 40. But its molecule is identical with its atom; hence, its atomic weight is 40, if it be an element, or the mean of the atomic weights of the gases constituting argon, if argon is a mixture of gases. The spectrum work of Professor Crookes argues that argon is a mixture of gases, while Professor Olszewski's work, showing that it has a definite melting point, a definite boiling point, and a definite critical temperature and pressure, and that on compressing it in the presence of its liquid, the pressure remains constant until all gas has condensed to liquid, strongly indicates, if it does not prove, that argon is an element. Further work alone can prove which view is correct.

Helium.

In April, 1895, Professor Ramsay was studying the nature of gases obtained by heating minerals, his object, no doubt, being to obtain argon in this way. From some minerals he did obtain argon, but from many of them he obtained a very light, colorless gas, that was lighter than argon and gave a different spectrum, and in particular gave a brilliant D_3 line in the yellow, which line had been noticed in the solar spectrum, but had never been obtained from an element on the earth. He named this gas helium, from ἥλιος, the Greek name for the sun. The D_3 yellow line had been observed thirty years before by Lockyer and Frankland, who supposed it to be that of a hypothetical element, which they named helium. Signor Palmieri, in Italy, some years since, obtained a soft substance from some ejected lava of Mt. Vesuvius that gave a yellow spectral line 587.5, the same as the D_3 line, but he gives no details. Dr. Hillebrand, of Washington, D. C., studied some years since, the gases occluded by minerals, in particular uraninites of various localities,[1] but found only nitrogen, as the spectrum of the gas obtained was that of nitrogen, and he obtained nitric oxide on sparking it with oxygen. He sent some of the uraninite to Professor Ramsay, who found that it did contain 10 per cent. of nitrogen, but also helium. The nitrogen masked the helium spectrum considerably, and, as Professor Ramsay says, it is likely that if Dr. Hillebrand had been working with clèveite he would have discovered helium. To extract the helium, five grammes of coarsely powdered mineral are heated in a glass bulb (made of hard glass) which has been exhausted by means of a Töpler pump. Thus are obtained CO_2, H, N, H_2O, and helium. Many rare minerals were examined, and the following yielded more or less helium in the order of their mention: Monazite, clèveite, bröggerite, pitchbende, xenotrim, orangeite, samarskite, yttrotantalite, hjelmite, fergusonite, tantalite, polycrase, etc. Professor Ramsay used mainly clèveite and bröggerite, because they were most available. Helium must be mechanically held by the minerals, since any of them, when heated and allowed to cool in helium, do not take up any of the latter. The impurities of the resulting gas were removed as follows: CO_2 by potassium hydroxide; water vapor by phosphorus pentoxide; hydrogen by sparking with an excess of oxygen, removing the excess of the latter by means of pyrogallic acid. The nitrogen was removed by repeatedly passing the gases over and through red-hot magnesium and its vapor.

The density of helium as the mean of five determinations was found to be 2.13 (O = 16). The half wave-length of sound in helium was found to be 101.5 mm. and in air 36.04 mm. By the same calculation as was given under argon above, it was found that helium is a monatomic gas. If the density as compared with H_2 is 2.13, and it is monatomic, then its atomic weight is 4.26. It is very slightly soluble in water, one volume absorbing only 0.0073 volume of the gas. This is the lowest solubility ever recorded. It is insoluble in absolute alcohol and in benzene. Its spectrum is made up of several lines in the red, orange red and yellow. Several lines are identical with argon lines; thus two in the red and one in the orange-red, but the bright red line of argon is faint in case of helium, and the bright red line of helium is faint in case of argon. The characteristic D_3 yellow line of helium is a doublet, one line of which is faint and the other very bright, the distance between them being about one fiftieth of that between the D_1 and D_2 lines of the solar spectrum.

An analogy exists between argon and helium. Both are very inert and cannot be separated when mixed, on account of their similarity in properties. Their densities and spectra, however, plainly prove their difference. Both are unattacked by oxygen when sparked with it, and both are unattacked by the vapor of magnesium. Both are monatomic and these properties differentiate them from all other elements. A most anomalous property of helium is its refractive index—which is about one-tenth that of hydrogen, a lighter gas—a fact which is as unlooked for as it is inexplicable. Why is argon in the air, and helium not there present, but confined to minerals?

Dr. Johnstone Stoney[1] probably gives the correct answer to this question. He shows that, if hydrogen were present in the atmosphere, it would at once leave this planet by virtue of the velocity of its own molecular motion, and migrate to a planet possessed of sufficient gravitational attraction, enough mass, to hold it fast. This, he says, accounts for the presence of helium and hydrogen in the chromosphere, and for the absence of an atmosphere and of water vapor on the moon. It would account for the absence of so light a gas as helium in our atmosphere, and for the presence of the helium line in the spectrum of the chromosphere. If an element forms compounds, or is absorbed by solids, it will be found on the earth; hence, we find helium occluded in minerals, while argon, which is so heavy and dense, can be held as such about our planet. Argon occurs in our atmosphere because it is so inert that it does not form any compounds, and nitrogen is there present because it is also inert and rarely enters into combination. Its compounds, too, are mostly decomposed by water, and the excess of nitrogen, hence, is in the air. Oxygen is in the air because there is an excess over what is necessary to oxidize everything on the surface of the earth. If there are gases similar to argon in inertness, and whose density is not less than that of nitrogen, they may too be looked for in the air. The density of argon is too high, and cannot be accounted for by assuming that it is a mixture of A_2 and A_1. As it clearly does not belong where its atomic weight places it in the periodic system, it must needs be a mixture, although its behavior near its critical temperature indicates that it is an element. There is, of course, no place for helium in the periodic system, as it lies between hydrogen and lithium. But we must not forget that there is no place for hydrogen, either, strictly speaking, and it may be that there may be an eighth group series at the beginning of our system, corresponding to the iron, nickel and cobalt, or the osmium, iridium and platinum series. If so, a third

1. Bulletin U. S. Geolog. Survey, 78, 43.

1 *Chemical News*, 1895, 71, 67.

gas of atomic weight between hydrogen and lithium is yet to be discovered. It has been mentioned that argon and helium have some spectral lines in common. As no lines of any two elements have ever been found to coincide as yet, we are confronted with the possibility that both these gases contain a common ingredient. The density of helium is, however, already so low that it is difficult to imagine that it contains as an admixture anything much denser; for to possess the density it now has, considered as a mixture, the true helium would have to be possessed of a lower density still; in other words, it would have to be lighter still than it now is. On the other hand, an admixture of helium with argon would tend to make the density of pure argon, and also its atomic weight, even heavier than it is. Hence, the supposition that they contain a common constituent is not fraught with much semblance of probability. We know that Professor Ramsay, Lord Rayleigh and many others are working at this most marvellously complicated array of phenomena presented by argon and helium, and, until more facts are forthcoming, it is useless to speculate what helium and argon are. *Veritas vos liberabit.*

The Electric Furnace in Chemistry.

The *Popular Science Monthly* reproduces from *La Nature* the following article, by M. H. Moissan, on the development by him and his associates of the electric furnace in its relation to chemistry:

The reverberatory electrical furnace with movable electrodes, which we devised in 1892, and in which we have made many improvements, is very simple in construction, has been of great service, and has permitted us to deal with problems which have been hitherto insoluble. By means of this apparatus we have been permitted, by obtaining a sufficient temperature, to produce the diamond, to crystallize metallic oxides, to reduce those which have hitherto been refractory, to melt metals heretofore infusible, to distil lime, silica, zirconia and carbon, and to cause an abundant volatilization of such metals as platinum, copper, gold, iron, manganese, aluminum and uranium. Some bodies that could not be brought to a condition of fusion, like magnesia, uranium, tungsten and molybdenum, could be made to assume the gaseous state in the electric furnace. In our studies we have frequently dealt with the vapor of lime and silica.

When using the currents of machines of from 100 to 300 horse power, we have in the midst of the furnace the temperature produced by the electric arc; a few centimeters beneath, the crucible containing the matter to be experimented upon; and at the bottom, a mass of quicklime in full ebullition. The imperfect conducting power of this substance is a fortunate quality for us. It isolates the heat which the electric arc can furnish into the smallest possible cavity.

This new apparatus permits us to approach the study of a whole series of simple bodies which have been till now mere laboratory curiosities, because of the want of adequate means of obtaining them.

It is easy, with the aid of the electric furnace, to produce abundant meltings of chromium by reducing the sesquioxide. This melting, refined, yields chromium, an unoxidizable metal very different from the specimens which have been hitherto obtained. It can be filed like iron, and takes a fine polish. Chromium, then, more infusible than carbon, can now be used in preparing alloys without the need of the intervention of ferro-chromium, which has the disadvantage of containing up to 10 per cent. of carbon.

This preparation opens the way for the effective study of the alloys of chromium. In combination with aluminum or copper, it gives interesting results. Pure copper, alloyed with 0.5 per cent. of chromium, assumes a double resistance and suffers less change than copper in contact with moist air.

Molybdenum, previously unfused, can also be obtained in notable quantities. By heating, in a continuous electric furnace, a mixture of oxide of molybdenum and charcoal, a melting of the metal is obtained which flows readily and can be easily molded. It furnishes a definite carburet, very well crystallized. It is refined by a new heating in the electric furnace, with an excess of oxide of molybdenum. The melted metal thus obtained has a fine grain and a brilliant surface. It can be filed and forged at a red heat, upon the anvil; and with iron it furnishes a steel that can be tempered. These are all new properties.

Tungsten has been heretofore known to chemists only as a powder. Under the action of the electric arc the oxide of tungsten is reduced by means of carbon, and gives in a few minutes a well-melted bottom, covered with a fine layer of the blue oxide of tungsten. This metal, which is still more infusible than chromium and molybdenum, can be liquefied with great facility. It does not seem to have a strong affinity for carbon, and is obtained without special precautions as one of the purest metals we have prepared.

The different oxides of uranium cannot be reduced by carbon at the ordinary temperatures of our furnaces, but when a mixture of the sesquioxide of uranium and carbon is subjected to the high temperature of the electric furnace, the reduction takes place in a few instants. After cooling, an ingot may be drawn from the crucible possessing a brilliant fracture and great hardness. When this uranium is slightly carbureted, it presents the property of striking fire in contact with flint. The particles thrown off burn with an intensity and an energy far superior to those exhibited by a piece of iron.

All these simple bodies melt at more or less high temperatures. By the side of them we may place other metals the minerals of which are rare—such as zirconium and vanadium.

Vanadium, on which Prof. Roscoe has made some interesting studies, was not known, except as a gray powder including hydrogen, oxygen, and a little of some alkali metal as impurities; but Prof. Roscoe has had the pleasure of seeing in my little laboratory at the Ecole de Pharmacie several hundred grains of it, under the form of cast metal pieces, having a crystalline and brilliant fracture. This simple body, the mineral of which occurs more extensively than is generally supposed, is very difficult to melt, it hardly liquefying in the current produced in the Edison dynamo by an engine of forty horse power.

In our studies of titanium, a mixture of charcoal and titanic acid, gave, with a machine of four horse power, protoxide of titanium; with a machine of forty-five horse power we obtained only nitride of titanium; under the action of currents of from 100 to 300 horse power we prepared by kilogrammes a crystallized carbide, and then real titanium, the properties of which are wholly different from those formerly attributed to the gray powders that bore that name. This substance takes fire in fluorine; decomposes water only at a bright red heat, and possesses the curious property of burning in nitrogen at a high temperature, yielding the nitride of titanium studied by Friedel and Guérin. It readily combines with carbon and silicon, but does not unite with argon. Its melting point is very high, it resembling carbon in that respect. It differs from carbon, however, in the fact that while carbon under the ordinary pressure and at a great elevation of temperature passes from a solid to a gas without becoming liquid, titanium can, in the electric furnace, be liquefied and then volatilized.

Most of the simple bodies furnish, with carbon, well-defined combinations, crystallized and stable, at a high temperature, which are destined to furnish a new chapter to mineral chemistry.

All these simple bodies which we have obtained by kilogrammes in the electric furnace form also borides and silicides finely crystallized and so hard that some of them easily cut the diamond. What part they are to have in the manufacture of steel, and whether they are destined, like chromium, to give new properties to iron, are questions for the future to answer. But a new chemistry of high temperatures is forming, from which industry will most likely draw numerous applications.

It is recognized on all sides that some of our industries are about to suffer important modifications through the use of electrical forces. We ask of the forces of Nature all they can yield; and they are capable of easy use when transformed into electricity.

Efficiency of Boilers with Varying Rates of Fuel Combustion.

By R. C. Carpenter.[1]

There seems to be but little data from actual experiment regarding this subject; what we can find indicates a decided lowering of the efficiency of the boiler as the rate of combustion increases. In the editorial columns of *Power* for November attention was called to the results obtained in a recent series of tests made by the writer under such conditions as incidentally gave some data bearing on this question. In the experiments quoted the rates of combustion did not vary between sufficiently wide limits to permit the enunciation of any general law connecting the evaporation per pound of coal with the rate of combustion.

A series of tests better suited for this investigation were made, however, in Philadelphia in 1868 by a board of engineers, on two boilers built for the purpose, one of which was a horizontal tubular the other a water tube boiler. Several hundred tests were made under different conditions and with varying proportions of grate and water heating surface, using in every case anthracite coal of good quality as a fuel. The complete results of these tests are given in Weisbach's Mechanics of Materials, Vol. II., Heat, Steam and Steam Engines (American Edition).

1. In *Power*, Dec., 1895.

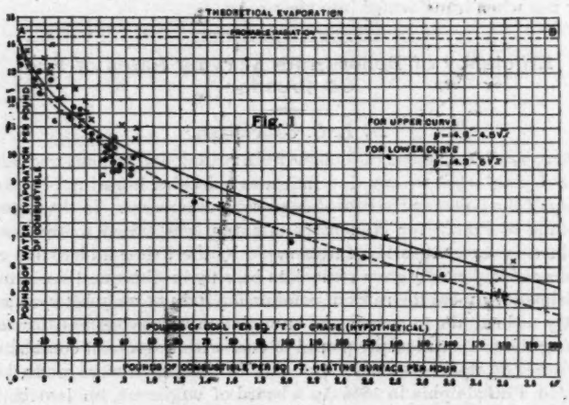
The writer has plotted the results obtained in the diagram Fig. 1, in which the abscissa or horizontal distance is the pounds of combustible actually burned per square foot of heating surface per hour and the ordinates or vertical distances, the pounds of water evaporated per pound of combustible from and at 212 degrees. A second horizontal scale is added above the first, which gives the pounds of coal that would need to be burned per square foot of grate per hour, provided the ratios of heating surface to grate had been maintained 45 to 1 throughout the tests, and further had the coal contained 11 per cent. ash. This is a hypothetical scale representing a condition which did not exist at time of making the test. The position of the actual results obtained with the water tube boiler are denoted on the diagram by (x). Those with the horizontal tubular by points surrounded by small circles. A full line is drawn at the top representing theoretical evaporation per pound of combustible for all cases, also a dotted parallel line, 5 per cent. lower, which represents the probable radiation loss as explained later. The curves which are drawn, and which represent fairly well the mean of all these various values within the limits of the test, are segments of parabolas having the horizontal axes in a b, the line which represents the theoretical evaporation per pound of combustible, less 5 per cent. radiation loss. The equation of the upper curve or that denoting the performance of the water tube boiler is $y = 14.3 - 4.5\sqrt{x}$; that representing the lower curve, or the results obtained in testing the horizontal tubular boiler, is $y = 14.3 - 5\sqrt{x}$.

In both these cases y equals the weight of water evaporated per pound of combustible from and at 212 degrees, and x represents the weight of combustible in pounds burned per square foot of heating surface per hour.

From the limited amount of experimental data bearing on the subject the writer is unable to predict how closely the above equations apply to boiler tests in general, but from the fact that the form of the curve represented by the equation agrees so well with the mean of the results obtained in the tests, it would appear as though the general law of variation with rate of combustion might be represented closely by an equation of this character. The equation in general form would be $y = b - a\sqrt{x}$. In this, b is the highest evaporation possible, and equals the theoretical evaporation per pound corrected for losses by radiation, x is the weight of combustible per square foot of heating surface per hour, and y is the number of pounds of water evaporated from and at 212 degrees.

The loss by radiation which is taken as a constant will depend upon the boiler setting and the protection which is given to the heated surfaces of the boiler. The writer has endeavored to determine the amount of that loss in all recent boiler tests which he has made, and has generally found it to vary within the limits of 3 and 10 per cent. In a recent summary of 21 boiler experiments by Mr. Bryan Donkin, in which all such losses were determined, this amount varied from 3 to 8.2, the average being not far from 5 per cent.

The experiments which have been quoted and which are represented in the diagram were made with anthracite coal, and in absence of experiments with bituminous coal one cannot say that the same law of


THEORETICAL EVAPORATION
FOR UPPER CURVE
FOR LOWER CURVE
POUNDS OF WATER EVAPORATED PER POUND OF COMBUSTIBLE
POUNDS OF COAL PER SQ. FT. OF GRATE (HYPOTHETICAL)
POUNDS OF COMBUSTIBLE PER SQ. FT. HEATING SURFACE PER HOUR
Fig. 1

variation would hold true. There is a market difference in the two kinds of coal, and the difference is of such a nature as to affect the values used in this equation. Thus, for instance, the heating values of anthracite coal are almost exactly proportional to the fixed carbon, which constitutes in every case nearly the entire amount of combustible matter. The difference in values of different anthracite coals is largely due to the amount of ash and "bone" contained, so that comparisons of different tests made with anthracite coal can be made fairly from the amount of combustible burned. When bituminous coal is burned the case is very different, for the reason that these coals contain large quantities of volatile combustible matter, and in no case do the results depend even approximately upon either combustible or refuse. The writer can see no reason, however, why the general equation should not apply to this case, by slight changes in the notation so that all units should be based not on combustible but on amount of coal

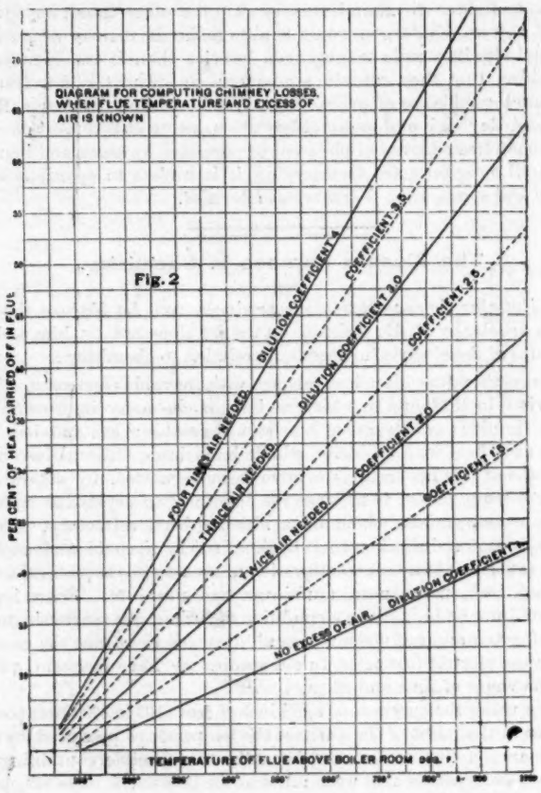


DIAGRAM FOR COMPUTING CHIMNEY LOSSES WHEN FLUE TEMPERATURE AND EXCESS OF AIR IS KNOWN
PER CENT OF HEAT CARRIED OFF IN FLUE
FOUR TIMES AIR NEEDED
DILUTION COEFFICIENT 4
THRICE AIR NEEDED
DILUTION COEFFICIENT 3.5
TWICE AIR NEEDED
DILUTION COEFFICIENT 3.0
NO EXCESS OF AIR
DILUTION COEFFICIENT 2.5
COEFFICIENT 3.5
COEFFICIENT 3.0
COEFFICIENT 2.5
TEMPERATURE OF FLUE ABOVE BOILER ROOM DEG. F.
Fig. 2

burned per square foot of heating surface and on the heat values in one pound of coal. Thus in the equation $y = b - a\sqrt{x}$, when applied to bituminous coal, y must equal the evaporation per pound of coal from and at 212 degrees, b the theoretical heating value of a pound of coal corrected for radiation loss and, a, a constant which depends upon the kind of boiler, the fireman and other conditions.

Theoretical Considerations.—There are certain theoretical considerations relating to the source from which the heat is obtained, and the magnitude and character of the various losses, which are of considerable interest in connection with such investigations, and while not serving to indicate a general law for variation, still may throw some light on the character of results found in the tests illustrated.

We have discussed the results obtained in some actual tests and shown the efficiency under certain conditions. The heat, which is applied in evaporating the water, is in part obtained by the direct radiation from the fire and in part from the heated products of combustion, which are brought in contact with the metallic surface of the boiler. The heat which is received by direct radiation from the fire is utilized in warming the water, in the lower portion of the boiler only or in those parts which are directly exposed to this heat. The heat which is obtained from the heated products of combustion is received through the metallic heating surfaces which are principally in such a position as to receive little radiant heat. Some experiments were made by Péclet to find the proportion that radiant heat bore to the total heat emitted, his results indicating that in the burning of wood 25 per cent. was radiated, in the burning of wood charcoal 50 per cent., and in burning oil 18 per cent. These experiments are to be considered as very approximate and simply indicate that from 25 to 50 per cent. of the heat may be radiated and that the other and remaining portion is carried away in the product of combustion. It is quite certain that the amount carried off in the product of combustion will vary directly with the percentage of air admitted into the furnace, and the remaining portion, or radiant heat, would form a greater portion of the total

as the amount of air admitted is less. The heat which is not absorbed by the surfaces of the boiler and utilized in generating steam, passes off in three ways; first with the heated gases into the chimney, second through the brick work and exposed surfaces of the boiler into the air of the room, which latter we will term the radiation loss, and third in evaporating any moisture or steam in the fuel (the heat in any steam produced in the furnace not in excess of the flue temperature passes off with the chimney gases), fourth, the heat which is removed with the ashes from the furnace.

If we compare the actual results with the highest possible results to be obtained from a pound of pure coal, two other losses are to be considered, namely, that due to imperfect combustion, and the other to the falling of unburned particles of coal into the ash pit. The following analysis indicates the various ways in which the total heat from the coal is obtained and applied:

- Total Heat.
  - Useful heat obtained { From Radiation. / From Connection. }
    - Depends on { Temperature. / Amount of Air. }
  - Waste Heat.
    - Chimney loss { Heat in waste gases. / In steam from moisture in fuel. / In gases due to imperfect combustion. }
    - Radiation.
    - Ashpit loss. { Heat in ashes. / Unburned coal. }

From the theoretical laws relating to the passage of heat through metals we learn that a certain rate of maximum flow exists, and that time is required in order that heat may pass through any given material. It is true that the time required is very short for the passage of radiant heat through a thin sheet of iron or steel, but the time required is considerably increased and is of sensible amount when the source of heat is hot air or heated gases, from which the heat is obtained by convection. A sensible time is required when heat has to pass through boiler scale or substances which are poor conductors. For the purpose of our argument the exact rate of heat transmission is not of great importance; but the fact that some time, even though small, is required for the heat to get from the fire and heated gases into the water is of importance, since if true it indicates that there must be a certain increased loss of heat with increased rate of combustion, and this statement, depending upon the fundamental laws of heat, must be true, regardless of the character of the construction of the boiler.

The heat which is lost in radiation, provided a uniform temperature of the boiler surface and the brickwork be maintained, will be independent of the rate of combustion, and is constant so long as the range of temperatures remains the same. The heat removed with the ashes is in nearly every case a very small percentage of the total, and it can usually be neglected in any boiler test as less than the probable error of observation. Thus, for instance, the specific heat of ashes is about 0.2, the maximum temperature which the ashes have when dropped into the ashpit is not often in excess of 2,000° F.; they rarely exceed 16 per cent. in weight of the total fuel burned. For the conditions above mentioned, the loss would be only 400 B.T.U. per pound of ashes, which is about one-third of one per cent. of the total heat in the coal when the ashes make only one-sixth of the total. The loss due to the imperfect combustion or the burning of the carbon of the coal into carbon-monoxide (CO) is practically nothing in the conditions which occur in ordinary boiler management. Imperfect combustion due to this cause can only occur when there is either a deficient supply of air or when the discharge gases are in excess of 2,000° F. It is seldom the case that there is a deficient supply of air; on the contrary, there is usually a great excess of air supplied, and the temperature of the flue gases is rarely higher than 500° F. So this loss is, for usual conditions, nothing. The loss due to particles of unburned coal falling through the grate bars and into the ashpit, though eliminated from our discussion of the tests, is a very serious one. This, as will be seen by looking at any ash pile, is of no small magnitude; it rarely falls below 20 per cent. of the ashes, and often runs as high as 50 or 60 per cent.—that is, it varies from 3 to 10 per cent. of the entire coal, and it is one which probably increases as the rate of combustion per square foot of grate increases.

The amount of moisture in coal varies greatly with the condition of the weather and the amount of exposure to which the coal has been subjected; it is seldom less than 3 per cent. and often runs to 8 or 10 per cent. Practically, this deducts in every case a corresponding amount from the evaporative power of the coal. It seems hardly necessary to remark that any heat expended in evaporating moisture[1] in the coal, is so much deducted from that which might be usefully applied. The heat which is lost in the chimney gases depends upon two quantities, the temperature and the amount of air which is drawn through the fuel. In order to obtain perfect combustion about 12½ pounds of air must be introduced for each pound of carbon, and about 36 pounds for each pound of hydrogen burned. Neglecting consideration of hydrogen (which does not exist in appreciable amounts in any anthracite coal) about one-fifth of the air is converted during combustion into carbonic acid, and the remainder passes away unchanged. The flue gases in case of perfect combustion will be composed of air, carbonic acid and steam. The specific heat of the gases is in every case practically the same as that of air; that of steam is about twice as much, and it will carry away twice as much heat per pound. The exact proportion of air can be determined by an analysis of the flue gases, which shows the relative amount of the various quantities. If there is no free oxygen present there is no excess of air; there will be, in case steam or hydrogen are absent, about 21 per cent. of carbonic acid. If twice as much air is introduced as required there will be about 10.5 per cent. of CO_2 and 10.5 per cent. of oxygen. If we term the number which represents the ratio of air actually found to that which is necessary for combustion the dilution coefficient, we may readily compute the percentage of loss of heat for different temperatures of the flue above that of the air in the room. These results can be represented graphically, by the following diagram (which is used as shown in the following example). If the chimney temperature is 500° above that of the air in the room, and no unnecessary air is supplied, the percentage of chimney loss is obtained by noting the intersection of the vertical from 500 to the first diagonal, and noting position on the left, for this case, it is 12.5 per cent. If twice as much air is supplied as needed the chimney loss will be 23 per cent. of the total heat liberated. While it is quite possible, with excellent management of the furnace, to keep the supply of air to about 1.5 of that required, as a matter of fact it is likely to run much higher, as the following results, taken from Boiler Experiments, by Messrs. Donkin and Kennedy,[1] would indicate that the average amount of air admitted is more than twice that required. Thus in a series of boiler experiments covering various types, the following values were obtained for the dilution coefficient:

Test.	Dilution Coefficient.	Test.	Dilution Coefficient.
1	1.58	11	1.81
2	2.4	12	2.00
3	1.63	13	1.56
4	2.6	14	2.00
5	4.3	17	2.8
6	2.8	19	2.7
7	2.8	20	1.6
8	2.0	..	...
		Average.....	3.04

The tests quoted indicate that the loss increases directly as the square root of the rate of combustion of the fuel; hence if the rate be quadrupled the loss is doubled. No theoretical reason can be given for this. But from the discussion it can be seen to be a very reasonable assumption, since some of the losses increase directly with rate of combustion, others are practically constant, so that the resultant loss might very reasonably be supposed to increase at an intermediate rate.

The equation which has been given as representing the results which were obtained in the tests made in 1868 applies very closely indeed to those tests which were recently made by the writer, and which are quoted in *Power* for November, 1895, as will be seen by the following brief statement:

No. of Tests.	I.	II.	III.	IV.	V.
Pounds of combustible per sq. ft. of heating surface per hour.....	0.38	0.398	0.64	0.85	0.45
Evaporation per pound of combustible from and at 212 actually obtained.....	11.39	11.4	10.2	12.01	10.31
Evaporation as above calculated by equation $y = 14.3 - 4.5\sqrt{x}$.....	11.5	11.46	10.7	11.9	11.3

It is seen that the calculated equations agree with the results very closely in four out of the five tests. This in some respects is to be considered accidental, for it is hardly probable that the same coefficients would be found to apply to boilers of different kinds and when operated under different conditions.

From the results of the investigations quoted, we see that in order to judge of the relative performances of any boiler we must take into consideration the rate of combustion of the coal during the test, as there is

1. A person buying wet coal is doubly cheated, since in the first place he pays for the water at the same rate as the coal, and in the second place this water reduces the power of evaporating water in the boiler.

1. London *Engineering*, September 20, 1895.

little doubt but that for any given construction the efficiency must increase as the total evaporation decreases. Whether the numerical laws stated hold in form and substance for all classes of boilers can only be determined by comparison with a large number of tests which are made in this manner.

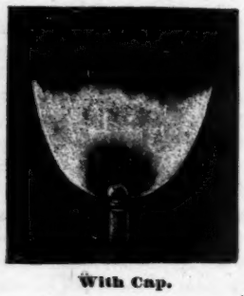
The Williams and Dean's Burner.

To the long list of inventions having for their object the enhancement of the lighting value of gas at the point of combustion is now to be added the Williams and Dean's burner cap, which is a contrivance certainly possessing the merit of simplicity, and, to all appearance, also possessing that of efficiency for the purpose intended. "Cap" burners, to be slipped over existing nipples, have been with us for years, and the fact they are in such general use attests how widespread is the appreciation with which they are regarded.

From the ordinary slit top cap and other contrivances of this class the Williams and Dean's invention differs in having as an outlet for the gas a series of fine radially drilled holes in the globular top of the cap, as shown in the accompanying cuts. The small flames resulting from the combustion of the numerous jets of gas issuing from these radiating holes coalesce to form a much larger flame, and one emitting much more light than would be given by the ordinary burner over which the cap has been slipped. The general nature of the change made in the flame from an ordinary No. 1 union burner by fitting upon it a Williams and Dean's cap is shown in the illustrations below.

The effects are especially marked with the lower numbers of burners, for example, Nos. 1, 2 and 3—careful tests with these burners showing that, using gas at 10-tenths pressure, a No. 1 union burner, consuming 3.1 cubic feet of gas per hour, and having a lighting value of 2.5 candles, had its lighting value raised to 8.34 candles when a Williams and Dean's cap was superimposed; an increase of considerably over 200 per cent. in lighting efficiency.

Without Cap.



With Cap.

Under similar conditions a No. 2 burner showed an increase in lighting value of 136 per cent., and a No. 3, 64 per cent. These results are undoubtedly very satisfactory, and as the figures have been borne out by subsequent independent testimony, and, indeed, can be easily verified by those who are curious in the matter, there seems reasonable ground for assuming that these burners will receive their share of attention. The accurate drilling of a dozen or more fine radiating holes in the steatite top of the cap must necessarily prove a more expensive item in the cost of manufacture than the formation of a mere slit, and we were therefore fully prepared to learn, upon inspecting a sample, that the price of this new burner is higher than that of the slit tops with which we have been so long familiar. Whether the higher cost is compensated for by proportionately increased efficiency we must leave for others to decide. It conclusion, it may be mentioned that the sole license in these burners, with respect to supplying gas undertakings, has been placed with Mr. William H. Harvey, 17 Old Queen street, London, S. W.—*Gas World.*

It is understood that a Pintsch system plant will be established in Washington, D. C., for the convenience of the Southern Railway Company, which concern proposes to in time equip all of its passenger coaches for lighting by means of compressed oil gas. The plant is to be located on the corner of 13½ and E. streets.

Nitrogen and the Nitrogen Products Derived from Coal.

The following is an abstract-translation, which appeared in the *London Journal*, of the paper read by Dr. Knublauch at this year's meeting of the German Association of Gas and Water Engineers at Cologne.

The behavior of the carbon and hydrogen of coal on distillation is the chief point of interest in gas or coke manufacture. At the coke ovens the aim is to obtain the greatest quantity of carbon as solid residue; in the gas works it is to hold as much carbon as possible in combination with hydrogen—and especially in those combinations which form the best illuminating hydro-carbons. The choice of coal and the conditions of production—more particularly the temperature of distillation—are the most important factors in producing the best illuminating gas. It has been shown that benzol and a small quantity of toluol are chiefly responsible for the illuminating power of gas, but exposure to a somewhat higher temperature will partially destroy them, with formation of graphitic carbon and so-called diluents. But besides the constituents of coal which on its distillation yield gases suitable for producing light and heat, there are certain other constituents, occurring in inconsiderable quantities, which claim attention. These are sulphur and nitrogen, of which the latter is the more important, since certain of its products have a very high market value. The nitrogenous products of distillation were regarded for some time as very troublesome, and even to-day in gas works are often considered of secondary importance, though costly ammonia-recovery apparatus is attached to coke ovens. The importance of the nitrogen products from coal will be sufficient justification for the publication of the following results of experiments and observations, made during a number of years at the Cologne Gas Works, and subsequently in the author's laboratory.

The amount of nitrogen is very variable in different sorts of coal, and even in the same kind. There is from 1.3 to 1.6 per cent. in Westphalian coal. The proportion that is converted to valuable compounds is, however, very small, forming only from 0.2 to 0.25 of the weight of Westphalian coal. The enormous amount of coal distilled daily in gas works and coke ovens makes the total quantity of these easily obtained compounds very large indeed. The daily demand of a million tons of coal over the whole globe corresponds to a yield of ammonium sulphate of about 10,000 tons daily, taking the nitrogen recovered as ammonia at 0.2 per cent. of the coal. The coal used at Cologne puts yearly into the gas retorts alone about 1,000 tons of nitrogen, of which 200 tons is recovered as ammonia and cyanogen; and these, reckoned as sulphate, may be valued at $62,500. It may appear remarkable that ten years ago we knew nothing of the remainder of the nitrogen, and only quite recently the matter of its disposition has been solved, in the course of a determination of the proportion which is converted to cyanogen.

We have seen that no certain relation exists between the nitrogen content of coal and the yield of nitrogen products; but until recently it was deemed correct to calculate the one from the other. This ignorance had two causes. On the one hand too little value was attached to chemistry in the gas industry (and this remains the case); and, also, until the nitrogen question was better understood, probably there was no gas works at which the products could be so separated as to enable any molecule of the coal distilled to be traced in any form in the products obtained. When this had been effected very well in Cologne, after the chemical bearings of the subject had been properly worked out, the nitrogen question again came to the front. The defects in wet purification and in the liquor works having been disposed of by chemical guidance, experiments showed that the ammonia completely extracted from the gas in the gas liquor yielded only 9.6 to 10 parts of sulphate per 1,000 parts of coal—corresponding to a percentage of nitrogen in the coal of nearly 0.2 only. Estimations of the nitrogen in the coal carried out at the same time showed seven to eight times that quantity, corresponding to 70 to 80 parts of sulphate per 1,000 parts of coal. Attempts to convert more nitrogen into ammonia were so far successful; but, on the other hand, disadvantages accrued, and the new processes were put on one side. The most memorable were the addition of lime to the coal before distillation, and the passage of steam over the incandescent coal and coke.

What becomes of the 86 to 88 per cent. of the nitrogen of the coal unaccounted for hitherto? A very small quantity occurs as cyanogen in the gas and as nitrogen bases in the tar, and there are only the coke and the gas where the residue may possibly be found. Actually, analyses showed a great quantity of nitrogen in the coke. The nitrogen content of the coke may even be higher than that of the coal, especially when the volatile nitrogen is small in relation to the total volatile matter of the coal. Nitrogen is not, like sulphur, detrimental to the use

of the coke, and estimations of it were not, therefore, carried out for the valuation of the coke. Without entering closely into the question we gain the impression that, with a higher temperature in the retorts, the nitrogen will not remain in the coke. After estimating in addition the nitrogen in the tar and the nitrogen as cyanogen in the gas, no other nitrogen compounds are in the products, and the surplus nitrogen must be free in the gas.

Exact results are scarcely obtainable in large-scale working, or only after long-continued trials, and, therefore, a laboratory apparatus was devised for distilling the coal. By this it was found that the generally possible yield of ammonia could be determined for various coals, and variations made dependent only on the choice of the coal. The results of experiments proved: (1) That the nitrogen content of the coal and its distribution among the different products are not in any degree proportional. For example, the yield of ammonia may be much greater from a coal of low than from one of high nitrogen content. This statement is also true of the other nitrogen products. Thus, a sample of coal containing 1.176 per cent. of nitrogen, yielded 0.1874 as ammonia; one containing 1.555 per cent. yielded 0.1850, and one containing 1.479 per cent. yielded 0.2086. (2) These variations are frequently very great with coal of different origin, and often small with the same kind, though even then they are sometimes very considerable.

Foster has investigated the question as far as English coals are concerned, and Schilling has made some experiments with various kinds. The yield of ammonia found is confirmed in the three series of observations. The yield for different kinds of coal in coke ovens working on the large scale has been also determined, and a series of coal distillations has been made in which the ammonia has been completely extracted from the gas and liquor. Though more recently introduced at the coke ovens, ammonia-recovery is often better carried out there than in many gas works. A large number of distillations of many kinds of coal have been made by the author to ascertain the yield in the various products. The average yield of sulphate of ammonia for coal from 15 different sources is shown in the following table:

Experiments on the Distillation of Coal.

Source of Coal.	Number of Tests Made.	Average Yield of Sulphate per 1,000 Parts of Coal.
Westphalia (*a*) gas coal	6	10.4 parts.
" (*b*) cannel (so-called).	3	7.7 "
" (*c*) coke oven coal	9	11.0 "
Upper Silesia (*a*) gas coal	1	13.5 "
" (*b*) coke oven coal.	8	
Lower Silesia (*a*) gas coal	2	7.7 "
" (*b*) coke oven coal.	3	8.4 "
Saar	6	8.2 "
England, gas coal	3	16.4 "
Belgium	1	6.8 "
Moravia, coke oven coal	3	10.6 "
Russia	1	11.8 "
North America	10	9.4 "
South America	1	13.3 "
Italy, lignite-like coal	2	28.9 "
Bohemia	2	7.4 "
Scotland, cannel	2	7.9 "
Spain	1	2.3 "
Australia	2	1.9 "

In choosing coal for gas making it is desirable to ascertain the yield of tar, ammonia and sulphureted hydrogen, as well as that of coke and gas. The difference in yield of ammonia varies in importance according to the current prices of ammonia compounds. The difference between 8 and 12 parts per 1,000 parts of coal would mean, to a works like Cologne, the difference between 700 and 1,050 tons of sulphate per year—that is to say, about $20,000 value. It is also of considerable importance to know the yield of sulphureted hydrogen from a coal, especially in cases where the purifiers have occasionally to be worked to their utmost capacity. This yield also is in no degree proportional to the amount of sulphur in the coal. It is easy to choose coal which shall not throw a great burden on the purifying plant.

Returning to the nitrogen, a close examination of the amounts converted to ammonia reveals here and there considerable discrepancies, even with coal of the same origin. Thus, two tests of Westphalian coal give 12.6 and 9.6 of sulphate respectively; two of Upper Silesian coal give 16.7 and 11.5 respectively. The above table reveals also very large differences in yield of ammonia in coals of different sources, English coal having the very high yield of 16.4 parts of sulphate per 1,000 parts of coal.

The differences in the yield of coals from the same source, one suited for gas making and the other for the coke ovens, are also striking, and as regards Westphalian coal the differences are exemplified in the results of the working at the gas works and at the coke ovens. This may be explained, since with the coals which produce more (or richer) gas and more tar, the affinity of hydrogen for carbon is favored at the expense of its tendency to combine with nitrogen.

Reverting to the distribution of the nitrogen among the different products, we will, for the sake of simplicity, compare three samples of coal. The results are given in the next table. The ammoniacal nitrogen here ranges from 11.9 to 15.9 per cent. of the total nitrogen. The Saar coal, with the lowest content of nitrogen, gives the highest proportion of nitrogen as ammonia. The differences in the nitrogen in the coke and gas are especially striking. With Westphalian coal, about one third of the nitrogen remains in the coke and one-half passes into the gas; with Saar coal, two-thirds is in the coke and one-sixth passes into the gas.

	Percentage of Nitrogen on the Coal.			Percentage of Nitrogen on Total Nitrogen.		
	Westphalian Coal. (1)	Westphalian Coal. (2)	Saar Coal.	Westphal'n Coal. (1)	Westphal'n Coal. (2)	Saar Coal.
Coke	0.4660	0.5260	0.7510	30.0	35.6	63.9
Gas	0.8560	0.6964	0.1896	55.0	47.1	16.1
Ammonia	0.1850	0.2086	0.1874	11.9	14.1	15.9
Cyanogen	0.0268	0.0268	0.0480	1.8	1.8	4.1
Tar	0.0212	0.0212		1.3	1.4	
Coal	1.5550	1.4790	1.1760	100.0	100.0	100.0

The import of this is seen in the effect on the percentage of nitrogen in the gas. On converting the weights of nitrogen yielded to the gas into volumes, and taking an average make of gas from the coal, it will be found that the gas from the coal contains a percentage of 2.4 and 2.0 with the Westphalian samples, and only 0.54 with the Saar coal of nitrogen derived from the coal itself. The behavior of the nitrogen is much more favorable to the gas with Saar coal, as the volume of this constituent, which so diminishes the illuminating power of the gas derived from it, is only one-quarter to one-fifth of the volume derived from the Westphalian coals.

The ammonia formed in the distillation of the coal must be completely secured in a marketable form. It will suffice, in this connection, to point out here that it is often easy to abstract the whole of the ammonia even with apparently inadequate plant. Recent observations have convinced the author that in many cases where only two-thirds to three-quarters of the ammonia was abstracted, a change in the working based on experiments resulted in the whole being secured, and without extension of either condensing or washing plant. No gas works should be content with much less than the yield of ammonia indicated in the table given above for particular kinds of coal—for instance, 10 or rather more parts of sulphate per 1,000 parts of Westphalian coal. Supposing a works of the size of Cologne only put two-thirds of the ammonia produced in the retorts on the market, the deficit due to the loss of ammonia would amount to about $15,000 net profit, while many indirect disadvantages would be incurred. About 0.2 to 0.6 part of sulphate per 1,000 parts of coal can generally be obtained from the water in the tar, and this is not usually recovered at the gas works.

[To be Continued.]

Correspondence

[The JOURNAL is not responsible for the opinions expressed by correspondents.]

Criticising Jacob Rees' Article on the Shrinkage of Cast Iron and Molecular Structure.

NORTHAMPTON, MASS., December 31st, 1895.

To the Editor AMERICAN GAS LIGHT JOURNAL:

Dear Sir—In your issue for December 30th is an article by Jacob Reese on "Shrinkage of Cast Iron and Molecular Structure," taken from the *Iron Trade Review*, and which contains so many statements at variance with the accepted theory of the molecular constitution of matter, that it ought not to be allowed to pass without a word of comment.

Without entering into a discussion of what Mr. Reese would probably call his "argument," it is sufficient for the present purpose to call attention to one or two single statements made in the article. "Atoms *per se* are inert." We know nothing about atoms *per se*—apart from the forces which they manifest; and whether the atom is the small, hard body, of Lucretius; the indivisible point which acts as a center of forces, of Boscovich; or a vortex in a perfectly fluid ether, as Sir Wm. Thomson (Lord Kelvin) has suggested, we know nothing nor are we likely to

know anything about its shape. There is absolutely no ground for assuming that the atoms of iron are "of the same shape as the earth," and that therefore "there exists between adjoining atoms what are known as chemical pores." When Mr. Reese makes the following assertion, "The atoms of each elementary body unite to form molecules in definite numbers, called chemical equivalents. The molecule of hydrogen is composed of 2 atoms, carbon 12, oxygen 16," etc., he simply exposes his profound ignorance of the whole matter by confusing the atomic equivalents, or more properly, the atomic weights with the numbers of atoms in the molecule—two totally different things. Most of the elementary gases and vapors have 2 atoms in the molecule; about the molecular size in liquids and solids almost nothing is known, except that the molecules are probably much more complex than is the case in gases and vapors.

To Mr. Reese and to others who may be interested in learning something about the present development of the theories of the molecular constitution of matter I should like to recommend an excellent little exposition of the subject by Mr. A. D. Risteen, of Hartford, which has recently appeared. S.

[The following brief review of the work by A. D. Risteen, S.B., entitled Molecules and the Molecular Theory of Matter, and published by Ginn & Co., 1895, is furnished by the author of the above communication for the benefit of the JOURNAL'S readers who may be interested in this subject.]

Mr. Risteen has done a real service to all who are in any way interested in the modern views in regard to the constitution of matter, by the publication of this little book. It is, so far as we are aware, the first attempt which has been made to place before the American and English reader anything like a complete and connected popular account of the elements of the physical theory of molecules as held to-day. And this attempt is justified not only by the need of such an account, but also by the thoroughly successful manner in which it has been accomplished.

The volume had its origin in a lecture delivered at the Worcester Polytechnic Institute, and though much new material has been added, the form of presentation has been preserved. The style is clear and easy, admirably suited to popular exposition, while the author shows throughout his entire competency for the task he has undertaken. An occasional page of mathematical formulas with the signs of differentiation and integration should not alarm the non-mathematical reader.

A treatise on molecules might readily be extended until it became a complete treatment of both chemistry and physics; hence Mr. Risteen has had to exercise much judgment in fixing the limits of his discussion. In the first place, he excludes entirely the chemical aspect of the molecule, and then endeavors to omit "all matter except that which has an immediate and evident bearing on *molecules*." While it is true that different men would hardly agree on the omissions which should be made, and some criticism may be passed on the selection which the author has finally decided on, we are not disposed to quarrel with him for his choice. All that he has given is good, and we could only perhaps wish that he had extended his bounds.

After a few pages devoted to a general consideration of the subject, the kinetic theory of gas, as set forth in some 70 pages, the molecular theory of liquids (28 pages) and that of solids (30 pages) follow, and two chapters on molecular magnitudes and on the constitution of molecules complete the book. In the last chapter Lord Kelvin's vortex theory receives due attention, and a brief review is given of the more famous and interesting theories which have been proposed to account for the "attraction" of gravitation.

While we are still very far from having anything like a complete theory of matter, a great deal has been accomplished in the last 40 years, and there is every reason to believe that the work is in the right direction. We have some fairly accurate information about the molecular constitution of gases, we know "a little about the constitution of liquids, and almost nothing, for certain, of solids." The general "order" of the magnitude of molecules is known, but nothing whatever is known of their constitution. "The chief difficulty before the philosopher who would investigate the structure of molecules lies in the fact that it is impossible to see or measure a molecule directly. * * * Our situation may be best illustrated, perhaps, by imagining a huge being who could observe only the general trend of events upon the earth—the march of civilization and the rise and fall of empires—and who desired to infer from these data the anatomy and mental characteristics of the invisible creatures whose individual acts, when summed up, had given rise to these phenomena. It is obvious that in either case the problem is of enormous difficulty, and that, to a certain extent, it may prove to be indeterminate."

Mr. Risteen has given a very interesting and suggestive account of the strenuous attempts of acute minds to fathom the mysteries of a region so inaccessible to the direct evidence of the senses. S.

ITEMS OF INTEREST FROM VARIOUS LOCALITIES.

MR. HENRY FITCH, Manager of the Bowling Green (Ky.) Gas Light Company, has been very successful in his well-directed efforts to popularize the use of gas for purposes other than lighting in that go-ahead Kentucky town. Mr. Fitch is a son of the late Col. H. D. Fitch.

ACCORDING to the report of the Superintendent of the Richmond (Va.) City Gas Works, the quantities of gas sold for the twelvemonth ended Dec. 31, 1895, were:

Month.	Gas Made, Cu. Ft.	Gas Sold, Cu. Ft.
January	25,579,900	24,451,442
February	19,646,500	19,620,171
March	19,802,000	19,839,112
April	15,851,200	15,841,053
May	15,059,200	15,070,295
June	10,921,800	11,107,113
July	11,485,800	11,468,668
August	12,057,100	11,909,251
September	12,857,400	12,869,378
October	18,640,500	18,741,160
November	21,475,300	21,367,925
December	24,188,200	23,748,678
Totals	207,564,900	207,034,306

Among other things, the Superintendent states that during the year 6,092 tons of coal, 8,633,293 pounds of coke, and 814,320 gallons of oil were used to produce the above named quantity of gas made. The quantity of lime used for purification was 9,740 bushels. The number of meters in use was 7,089; the number of new consumers taken on during the year was 266; the street lamps number 1,647; 192 service pipes were renewed; and the street main system covers 71 miles of territory. During the months of November and December the residents in the section of the city lying west of Laurel street and south of Broad street were much inconvenienced in obtaining an adequate supply of gas, which trouble was occasioned by the small diameters of the pipes in that district. On the representation of the Superintendent, the City Council appropriated the sum of $16,000 for pipes of a capacity suitable to the lighting needs of the territory, and the work of laying the mains is now underway.

THE annual election for Directors for the Yonkers (N. Y.) Gas Light Company will be held at noon of the 15th inst.

THE Board of Trustees of the Wheeling (W. Va.) City Gas Works has determined to go back to the use of lime for purifying purposes. We imagine, however, that oxide would not have been abandoned had the purifying boxes been of a size somewhere near commensurate to the fair task of passing the quantity of gas that was being forced through them. No; the fault was not with the oxide.

THE annual meeting of the shareholders in the Cleveland (O.) Gas Light and Coke Company will be held at 2 P.M. of to-morrow.

THE Haverhill (Mass.) Gas Light Company's main system has been extended to the district known as Peabodyville.

THE Twelfth General Meeting of the American Chemical Society was held this year in Cleveland, Ohio, the proceedings being directed by the President, Prof. E. S. Smith, of the University of Pennsylvania. A feature of the convention was the address of welcome to the delegates, which was delivered by Mr. M. S. Greenough, of the Cleveland Gas Light and Coke Company.

A CORRESPONDENT at Belvidere, Ills., forwards the following: "At a meeting of the shareholders of the Belvidere Gas Light and Fuel Company, held some days ago, it was unanimously voted to accept the plant, which had been constructed by Messrs. Campbell & Henley. The Company is capitalized in $50,000, of which amount $30,000 is owned by residents of Belvidere, Messrs. Campbell & Henley controlling the balance. Mr. F. S. Rowan is the Manager of the Company, which bids fair to have a successful career."

THE following interesting opinion was recently handed down by Mr. Justice Archibald, in the case of Mr. and Mrs. Waldron, versus the town of Westmount, Canada, plaintiffs praying for a mandamus against defendant:

"The plaintiff alleges that she is proprietor of a certain property, situate within the limits of the town of Westmount, which she occupies, and which is fitted up to be lighted with gas, and that she desires to light the same with gas, and that no mains are laid down to enable her to do so; that there are mains, belonging to the Montreal Gas Company, in a street within the said municipality, known as the Cote St. Antoine road; that Claremont avenue runs from Cote St. Antoine road, and passes plaintiff's property; that the Montreal Gas Company is willing to lay down pipes in said avenue, and furnish gas to plaintiff upon receiving defendant's permission to open the street for that purpose, which defendant refuses to give; that defendant has permitted various other citizens in its municipality to be furnished with gas by the said Montreal Gas Company, and that in refusing permission to the said Montreal Gas Company to open the surface to lay mains in Claremont avenue, they are treating petitioner (plaintiff) in an unjust and illegal manner, and petitioners pray that a writ of mandamus be granted, ordering the said defendant to allow and give permission to the petitioner, and to the Montreal Gas Company, to open the streets called Claremont avenue and Cote St. Antoine road, for the purpose of laying pipes for the furnishing of gas to said petitioner. The respondent, upon the said petition, pleads, by first plea, denying the petitioners' allegations, and, by a second plea, alleges the right of defendant to exercise an official judgment and discretion as to the opening of streets for the laying of gas pipes therein, and denying the right of the courts to interfere with the exercise of such discretion. That, moreover, respondent has obtained power, under the provisions of 58 Victoria, Chap. 54, to instal a gas plant for the furnishing of gas to defendant's citizens; that said Montreal Gas Company having attempted to lay pipes in defendant's streets without permission defendant caused said Company to be enjoined from doing so, by judgment rendered by the Hon. Justice Gill, on the 13th April, 1894, That the present proceeding by petitioner is only colorable, and is an indirect attempt on the part of said Montreal Gas Company to avoid the injunction above referred to, and that, moreover, defendant, in order to comply with petitioners' wish to have gas, itself placed, in said Claremont avenue, pipes for the conveyance of gas from the main of the Gas Company, situated in Cote St. Antoine road, to the petitioners' residence, but that the petitioners and the said Montreal Gas Company neglected to avail themselves of the said gas pipes. That defendant is taking steps to supply its citizens with gas. The said Council have determined that it is against the public interest to allow the Montreal Gas Company to extend its pipes in their municipality. Defendants pray the dismissal of the writ of mandamus with costs. It is shown in proof that, for a considerable period of years, the Montreal Gas Company has been supplying gas in the territory now constituting the town of Westmount, and, although defendant alleges that no act of its Council, nor of the Councils of municipalities under other names previously occupying said territory, had, in express terms, granted the right to open and use the streets of said municipality generally, for the purpose of laying gas pipes, yet it appears that said municipalities had contracted with the said Gas Company for the lighting of the public streets within the municipality, or of some of them, which involved incidentally the rights to do the works necessary to perform that service. More lately, however, the municipality in question, then known as Cote St. Antoine, contracted with one Coates to supply gas to the municipality upon terms stated in the contract, which contract was subsequently transferred to a Company known as the Consumers' Gas Company, which was constituted by said Coates, but after this Company had laid a considerable length of pipe, and had commenced lighting the municipality, it sold out its property and franchise to the Montreal Gas Company. This latter Company, however, refused to carry out the contract of the Consumers Gas Company with the defendant as to the price of gas to be furnished to the citizens. The Montreal Gas Company thereupon attempted to open the streets, for the purpose of laying mains, without permission of the defendant's Council, and were met by a writ of injunction, which was, as above stated, made absolute by judgment of Mr. Justice Gill, in April, 1894. That case was carried into appeal by the Montreal Gas Company, but does not appear to have been actively prosecuted in appeal, as, although over 18 months have now elapsed, the case has never been brought to argument. The defendant has, since the period in question, while refusing permission to it to lay new mains, granted numerous permissions to the Montreal Gas Company to lay service pipes into the houses abutting on the streets where mains already existed. The sole question raised in this cause is as to whether a citizen who lives upon a street where no main exists can, on the allegation that other citizens living on other streets are being supplied with gas, compel the municipality to provide mains for the supply of gas to him, for the reason that the defendant was obliged to treat all its citizens with equality. There is no doubt that it is the duty of a municipality to maintain, in its dealings with the citizens and its decisions concerning all municipal matters, strict impartiality and equality among all the citizens so far as that is possible; yet, on the other hand, it can scarcely be asserted that, because the citizens who happen to live upon one street had certain privileges, that those who happen to live upon any other street could, as a matter of right, demand that they should have the same privileges. The Council of a municipality, for instance, resolved that a certain street shall be paved, as for example, with wood or asphalt—could the property owners upon every other street demand similar pavements for their streets, and, upon refusal of the Council to accede to their demands, would they have the right to ask the Court to compel it by mandamus? One might illustrate by reference to almost every municipal service; if such a right existed the government of a municipality would be impossible. The Council must have a discretion to exercise as to the manner in which the various municipal services shall be performed. The members of the Council act in all such matters subject to their responsibility to the electors, and if they exercise their discretionary functions in an unjust manner, they must answer to the electors for it." Justice Archibald then quotes several authorities whose opinions support the views above expressed, and concludes his judgment by saying: "I am of the opinion that the facts proved do not warrant the Court in interfering with the exercise of the defendant's discretion with regard to the opening of streets within its municipality for the laying of gas mains therein, and the mandamus must be quashed with costs."

THE Berlin Iron Bridge Company, of East Berlin, Conn., has just completed, for the Windsor Company, at North Adams, Mass., a new fireproof storehouse, the dimensions of which are 70 feet in width by 125 feet in length. The construction is composite, of iron and brick, no woodwork whatever being used. The floors are of terra cotta.

GAS was first used in San Francisco, on the evening of February 11th, 1854. A feature of the occasion was a banquet at the Oriental Hotel, at which the San Francisco Gas Company entertained a great many of the leading citizens of the city.

ON April 1st, 1895, the Freeport (Ills.) Light and Fuel Company assumed control of the plant and possessions of the Freeport Gas Company, and the new management has made many improvements since then. Among the betterments we may mention a new gasholder and tank, a new and complete purifying plant, equal to dealing with a daily make of 250,000 cubic feet—Mr. Fred Bredel was the constructor thereof; a 6 foot station meter, built by the Maryland Meter and Manufacturing Company, and a new 6-inch street main governor, of the Connelly type, was installed. The street main system was also overhauled and extended, some pipe as large as 12 inches in diameter having been laid. As might have been expected the increase in the gas output under the new management—the selling rate was put at $1.35 per 1,000 cubic feet—and under the improved methods of working has been extremely satisfactory. In fact, one month (July last) showed a gain of 51 per cent. The residents are well pleased over the service given by the Company, and much praise is heard respecting the success of the Welsbach lamps, both for indoor and outdoor lighting. The proprietors of the Company, however, do not propose to consider that the plant is yet perfect, for they have about decided to erect an entirely new generating plant this spring, the construction to be in all likelihood of the coal gas type, full-depth regenerative furnaces to be a feature of the equipment. The officers of the Company are: President, C. D. Knowlton; Vice President, Jacob Krohn; Treasurer, Wm. O. Wright; Secretary and Manager, Z. T. F. Runner.

THE reduced rate of $1 net per 1,000 cubic feet for gas used for illuminating purposes, determined upon some weeks ago by the management of the Laclede Gas Light Company, of St. Louis, Mo., went into effect on the 1st inst. It was also agreed that the net rate for gas used for cooking, heating and power purposes should be put at 80 cents per 1,000 cubic feet; but owing to the fact that this scheme would necessitate the placing of separate meters for illuminating and fuel use, and as the work of setting the measurers would take some months for its completion, the Company, preferring that the reduction on fuel account should

take effect at the same time with all consumers, informs its customers that the 80 cent rate will not become operative until July 1, 1896.

ANOTHER phase of the tangle in which the Hastings (Neb.) Gas Light Company is enmeshed is shown in foreclosure proceedings instituted about a fortnight ago, by the Farmers Loan and Trust Company, of this city, on account of default of interest on a $30,000 mortgage, for which the Trust Company is the trustee. The judge before whom the proceedings were brought ordered the sheriff to take charge of the property, and instructed him to keep the plant in operation until the case can be argued. This action will prevent the sale of the plant, which was advertised for Wednesday next, as the result of a levy by another creditor.

MR. FRANCIS BRADNER has been appointed to a responsible position by the parties in charge of the scheme for the consolidation of all the gas properties on the New Jersey Coast, between Red Bank and Ocean Grove.

A RATHER mysterious trio of incorporations are those filed by Messrs. Henry S. Paul, John J. White, John W. Baker, Edward T. Taylor and Talbot L. Hibberd, who give notice that, on Friday, January 24th, they will apply to the Governor of Pennsylvania for charters for gas companies for the places named below—the applications are made under the Pennsylvania law enacted April 29th, 1874: For the "Gas Company of Pottsville, to manufacture and supply gas for light only to the public at Pottsville, Port Carbon, Palo Alto, Schuylkill Haven, Cressona, North Mannheim township and all contiguous territory;" for the "Gas Company of Bethlehem, the character and object of which is to manufacture and supply gas for light only to the public in the boroughs of Bethlehem and South Bethlehem;" and for the "Gas Company of Allentown, the charter and object of which is to manufacture and supply gas for light only to the public in the city of Allentown," etc. The moving spirit in this proposed wholesale grab seems to be Mr. John J. White, who says that his business is that of a solicitor, and who gives his headquarters as 925 Chestnut street, Philadelphia.

SINCE writing the above we learn that the same parties have scheduled still another location in their scheme. They will ask for a charter for "The Gas Company of Altoona, the object of which is to manufacture and supply gas" to the residents of "Altoona and Tyrone, and to the townships of Logan and Tyrone."

STILL another to be added to the proposed "White" Companies is reported from York, Pa. The concern is to be known as "The Gas Company of York," and the terms of the application are similar to those mentioned above.

THE Gettysburg (Pa.) Gas Company announces the following changes in its executive management: President, Mr. J. W. Diehl; Prof. P. M. Bikle, elected a Director, to succeed the late Hon. Edward McPherson; Mr. J. Bushman as Collector, to succeed the late Jacob Remmel.

THE annual meeting of the stockholders in the New Haven (Conn.) Gas Light Company was held on the 2d inst. Out of the 40,000 shares in the Company, only 22,355 were represented and voted on. The President, Mr. Andrew DeForrest, directed the proceedings. The annual reports showed that the Company was prospering. The Directors chosen were: Chas. R. Ingersoll, George J. Brush, Francis Wayland, A. W. DeForrest, E. Hayes Trowbridge, Pierce N. Welch, George D. Watrous, Robert A. Brown and T. Attwater Barnes.

THE annual meeting of the Consumers Gas Company, of Woodbury, N. J., was held on the 2d inst. After a prolonged discussion it was resolved to order a reduction in the selling rate, from $1.90 per 1,000 cubic feet to $1.65 per 1,000, the concession to date from the 1st inst. The officers chosen were: Directors, G. G. Green, M. W. Newton, C. C. Jessup; President, H. C. Clark; Vice-President, G. G. Green; Secretary and Treasurer, C. W. Starr.

THE Citizens Gas Company has notified the residents of Stoneham, Mass., that the selling rate is to be increased to $2.50 per 1,000 cubic feet; and the Stonehammers are accordingly stirred up over that determination.

THE eastern syndicate that recently purchased the plant and franchises of the Excelsior Gas and Coke Company, of Topeka, Kas., is said to include ex-Governor R. P. Flower, Mr. W. A. Olcott, President of the Central Trust Company, of this city, and Mr. A. N. Brady. It is also said that Mr. H. L. Morgan has been appointed Secretary of the Company, vice Judge Clark, who managed its affairs for many years.

ACCORDING to the Boston *Post* the output of the four Companies forming the Bay State Gas Company, of Boston, for the six months ended December 31, 1895, as compared with the output for the corresponding months of 1894, shows an increase of 12.83 per cent. The detailed output follows: Boston Gas Company, 539,717,000 cubic feet; increase, 30,494,000 cubic feet, or 5.90 per cent. Roxbury Gas Company, 112,246,000 cubic feet; increase, 22,677,000 cubic feet, or 25.31 per cent. Dorchester Gas Company, 76,454,000 cubic feet; increase, 21,500,000, or 39.14 per cent. South Boston Gas Company, 52,294,000 cubic feet; increase, 14,155,000 cubic feet, or 37.11 per cent.

A VERY pleasant occasion was the fifth annual dinner of the employees of the Hamilton (Can.) Gas Light Company, which was held at Newport's hostelry on the night of December 30th. Mr. William Ashby occupied the chair, and the festivities were shared in by 60 of the Company's men. The guest of the evening was Mr. Thomas Littlehales, who had been the Company's Manager for about a quarter of a century, but who had agreed to assume the responsible position of Resident Engineer to the Syracuse (N. Y.) Gas Company, thus severing the ties that unstrainingly bound him to the fortunes of the Hamilton Company and to the welfare of its workmen. Mr. Littlehales, in responding to the toast of "Our Guest," said it was with much pleasure and gratitude that he acknowledged the faithfulness and friendship of those who had served with him for such a long period of time. He had found them at all times ready to serve the Company and its Manager, as only good and tried servants can. He was sorry over parting with them, but in his new field of duty he assured them that his best thoughts and heartiest wishes would always be for them all. He spoke of his successor (Mr. Edmund Cathels) as a man of sterling worth—one whom they would respect, for he was liberal, honest and true in his dealings with all men. Other speakers were Messrs. J. F. Leishman, J. H. Mawson, W. J. Fearman and Wm. Newport. A violin solo (by Sydney C. Littlehales), an instrumental duet, and many songs added to the enjoyment of the guests.

Rock Temperatures in Depth.

In the December number of the *American Journal of Science*, Professor Agassiz says: For several years past I have, with the assistance of our engineer, Preston C. F. West, been making rock temperature observations as we increased the depth at which the mining operations of the Calumet and Hecla Mining Company were carried on. We have now attained at our deepest point a vertical depth of 4,712 feet, and have taken temperatures of the rock at 105 feet; at the depth of the level of Lake Superior, 655 feet; at that of the level of the sea, 1,257 feet; at that of the deepest part of Lake Superior, 1,663 feet; and at four additional stations, each respectively 550 feet, 550 feet, 561 feet and 1,256 feet below the preceding one, the deepest point at which temperatures have been taken being 4,580 feet. We propose, when we have reached our final depth, 4,900 feet, to take an additional rock temperature, and to then publish in full the details of our observations.

In the meantime it may be interesting to give the results as they stand. The highest rock temperature obtained at the depth of 4,580 feet was only 79° F.; the rock temperature at the depth of 105 feet was 59° F. Taking that as the depth unaffected by local temperature variations we have a column of 4,475 feet of rock with a difference of temperature of 20° F., or an average increase of 1° F. for 223.7 feet. This is very different from any recorded observations; Lord Kelvin, if I am not mistaken, giving as the increase of 1° F., 51 feet, while the observations based on the temperature observations of the St. Gothard tunnel gave an increase of 1° F. for 60 feet. The calculations based upon the latter observations gave an approximate thickness of the crust of the earth, in one case of about 20 miles, the other of 26.

Taking our observations, the crust would be over 80 miles, and the thickness of the crust at the critical temperature of water would be over 31 miles, instead of about 7, and 8.5 miles as by the other and older ratios. With the ratio observed here, the temperature at a depth of 19 miles would only be about 470°, a very different temperature from that obtained by the older ratios of over 2,000° F. The holes in which we placed slow registering Negretti and Zambra thermometers were drilled, slightly inclined upward, to a depth of 10 feet from the face of the rock, and plugged with wood and clay. In these holes the thermometers were left from one to three months. The average annual temperature of the air is 48° F., the temperature of the air in the bottom of the shaft was 72° F.

THE AMERICAN GAS LIGHT JOURNAL

A. M. CALLENDER & CO.,
PROPRIETORS.

MONDAY, JANUARY 13, 1896.

Carbonic Acid as a Refrigerant.

In the past few years carbonic hydride, or carbonic acid, as it is usually called, has forged rapidly to the front as a refrigerant throughout Europe. Hitherto mechanical difficulties have prevented its adoption, but these have been entirely overcome, and now over 500 machines are in use and giving entire satisfaction. This is the more noteworthy, as it has made especial strides in Germany, the birthplace of mechanical refrigeration. Fuel there is a very expensive item, and only the most economical devices are adopted. Compound and triple expansion engines, with condensers, are used largely, and the same economy is practiced in the selection of ice and refrigerating machines.

Recently manufacturers of a carbonic acid machine obtained a contract, in open competition with all the best ammonia machine manufacturers, for the refrigerating plant in the city slaughter house in Carlsruhe, because their guarantee as to the amount of power and cooling water was better than any other. In the official test, by Professor Brauer, it was found that 25 per cent. less power and cooling water was required than had been guaranteed.

Besides its economical action, it has advantages over ammonia and other refrigerants now in use. Its boiling point at atmospheric pressure is 108° below zero, F., so that a most intense cold can be produced by its use. It is a commercial commodity, largely used in the universal soda water fountains, and is easily obtained at one-third the cost of ammonia. It is odorless and non-corrosive. To those familiar with the corrosive effects of ammonia, this latter advantage speaks with all the more force. Brass, copper and other materials can be used in the construction of the carbonic acid machine. In the event of an escape of gas, no serious damage can occur, as in the case of ammonia. The experiment of allowing the entire charge to escape into the engine room has been tried, without affecting in any way the engineers or others in the building. This makes the machine especially adapted for marine service, and for use in hotels, where an escape would be especially harmful.

As carbonic acid is a component of beer, it is the machine for the brewery. In the event of any escape, beer would be improved, if anything, while there can be no question of the deleterious effects of ammonia on beer. Brewers can collect carbonic acid arising from their fermenting tubs, compress it, carbonate their entire product and also use a portion to refrigerate their plant. As it has a preservative effect on meats, it is also the refrigerator for packers and cold storage men. With ammonia meat would be blackened and spoiled in the event of a leak. In the event of fire, carbonic acid also has an advantage over ammonia. The latter tends to extinguish an incipient blaze, but with high temperatures becomes an explosive. Carbonic acid will act as an extinguisher at any temperature. Carbonic acid is a much denser gas than ammonia, so that in spite of the higher pressure there is really less danger of an escape. The machine itself is of the compressive order, consisting merely of a compressor, condensor and refrigerator. It has no oil pump, oil separator or oil cooler to complicate it. As the cylinder volume required is very much less than with ammonia, the cylinders can be made much smaller, and the whole machine more compact. As the parts are all small, it is a very easy matter to design them so as to stand the higher pressure reqnired. As the diameter of the cylinder is less, there is less friction and less power required. Although there are a few machines of this type in America in operation, they have not been largely introduced. The Cochran Company, with works and office located at Johnstown, Pa., have been recently formed, and will push the manufacture of the machines.—*Iron Age.*

How to Build a Chimney.

Simple as it may seem to build a brick chimney and top it out, it is seldom done in a first-class and workmanlike manner. In the first place, especially in wooden houses, the best and hardest brick are selected for the outside walls, or the underpinning, and the soft brick and bats are put into the chimneys. Anyone with a practical knowledge of the requirements of chimney flues will at once recognize the folly of this method, says a writer in the *Brick-builder.* To be sure, they generally use good brick for the top, but it is up through the inside where there is danger of the fire eating through the soft brick and heating the timbers so that sometimes they become completely charred, and many disastrous fires have been traced directly to this cause. The use of tile flue lining, which we are glad to note is rapidly coming into general use, overcomes this evil to a certain degree. Many round tile are now placed in square flues, the tile being used for smoke and the four corners of the flue for ventilation.

In topping out a chimney there is a wide difference of opinion as regards the best materials to use as mortar. It has often been remarked that houses built in "ye olden times" had chimneys laid up with simple lime mortar, and when it becomes necessary to tear them down, to make room for more modern structures, they have been found in a good state of preservation; in fact, it is often a hard matter to separate the bricks from the mortar. With a knowledge of this fact, many authorities claim that the masons of to-day do not use as good mortar as the masons of long ago. Their opinion is certainly open to severe criticism. In the first place, they used wood as fuel almost entirely, whereas the common fuel to-day is anthracite coal.

As almost every one knows, the gases generated by the consumption of the fuel employed are the prime destructors of chimneys decomposing and destroying the life of the mortar employed, and causing the softer bricks to chip and flake. Now, the gases thrown off from a wood fire are not strong enough to make any perceptible effect on a well constructed chimney; but when coal is the fuel we find a far different state of affairs, and just here we find the reason why the chimney built 100 years ago did not fall to pieces in a few years, like those of the present day. Having found that the gases, or condensation of gases, are the chief factors in the destruction of the chimney, we must employ those materials least susceptible to their ravages, and the experience of some of the most practical mason builders in the country has suggested the following rule: Use only the best and hardest brick throughout the entire chimney, laying them in best lime mortar to roof, and be particular to fill all joints full. Above the roof use mortar composed of 1 part lime and 4 parts cement, with sand enough to work smooth. The plainer the chimney top is in design the better. Saw tooth work and similar ornamentation should be avoided, and the largest chimneys should not be drawn out at the head more than 8 inches in each direction. Keep the inside of the flue straight and smooth. Change the bond in setting out the projections in the head to avoid the use of small pieces or "Dutchmen." Do not make the top course smaller than the shaft of the chimney. On top of the brickwork put a stone coping and fasten the dowels with melted lead, and on top of this coping put a flat, smooth stone, supported at each corner by small blocks of stone, whose height must depend on the size of the flue or flues. A strict observance of these rules will give as a result a well built, safe and durable chimney, which will not be affected by the weather or gases nearly as soon as those built in the ordinary manner.—*Carpentry and Building.*

The Market for Gas Securities.

Weakness was the prevailing characteristic of the gas share market of the week, Consolidated being especially dull and depressed. The trading on the Exchange yesterday (Thursday) in this security amounted to only 485 shares. Of that lot, 300 shares were disposed of at 144. The opening came in to-day (Friday) at 145½ bid, 146½ asked. Equitable is also dull and lower, at 196 to 202. Mutual holds its own fairly well. New York and East River common shows a loss of half a point for the week in the bid price, as also does the preferred. Standard common is weaker, but the preferred is steady, at a shade better than last quotation.

Speaker Fish has announced the composition of the Assembly Committees for the session, those named to the Committee on Gas, Electricity and Water being Messrs. Lounsberry, of Ulster, Braun, of Erie, Cutter, of Rockland, Goodsell, of Orange, Brownell, of Broome, MacNaughton, of Saratoga, Taylor, of Oswego, Messitter, of Sullivan, Forrester, of Kings, Cole, of Wyoming, Finn, of New York, McKeown, of Kings, and Corrigan, of New York. It looks to be an oddly assorted lot, with the backwoods fairly well represented. The Chairman is undoubtedly a representative man, still the only Gas Company of anything like importance is that at Kingston. We can but wait.

There is nothing new in the Brooklyn situation, unless it be that many complaints are made as to the quality of the gas distributed and that 75 seems to be finally agreed upon as a fair price for the stock of the Brooklyn Union Company. Chicago gas has had its ups and downs, although in the main it held fairly firm. The opening to-day in it was 64¾. Baltimore Consolidated is weak, but from sound advices we incline to the belief that it is a purchase, basing the opinion on the thought that gas rates in Maryland will not be disturbed by the Legislature. Laclede common is weaker, at 18½, and Bay State is neglected and flat. Consumers, of Jersey City, shows no recovery from the decline of a month ago. Western gas, of Milwaukee, is offered at 65, ex-div.

Gas Stocks.

Quotations by Cochran & Close, Brokers and Dealers in Gas Stocks.

35 Wall St., New York City.

January 13.

☞ All communications will receive particular attention.
☞ The following quotations are based on the par value of $100 per share.

N. Y. City Companies.	*Capital.*	*Par.*	*Bid.*	*Asked.*
Consolidated	$35,480,000	100	145½	146½
Central	500,000	50	150	..
" Scrip	220,000	..	100	..
Equitable	4,000,000	100	195	..
Bonds, 6's	1,000,000	1,000	105	..
" 1st Con. 5's	2,300,000	1,000	114	..
Metropolitan Bonds	658,000	..	108	112
Mutual	3,500,000	100	215	230
" Bonds	1,500,000	1,000	100	102
Municipal Bonds	750,000	..	..	..
Northern	150,000	50	79	80½
" Bonds	150,000	1,000	..	98
New York and East River	5,000,000	100	28	31
Preferred	2,000,000	100	62	67
Bonds 1st 5's	3,500,000	1,000	97	98½
" 1st Con. 5's	1,500,000	..	90	90¼
Richmond Co., S. I.	348,650	50	50	..
" Bonds	100,000	1,000	..	..
Standard	5,000,000	100	67	69
Preferred	5,000,000	100	103	106
Bonds, 1st Mortgage, 5's	1,500,000	1,000	105	..
Yonkers	299,650	50	112	..
Gas Co's of Brooklyn.				
Brooklyn	2,000,000	25	140	..
Citizens	1,300,000	20	70	..
" S. F. Bonds	320,000	1,000	..	101
Equity	2,000,000	10	..	..
" Bonds	1,000,000	..	..	..
Fulton-Municipal	3,000,000	100	220	..
" Bonds	300,000	..	108	..
Peoples	1,000,000	10	100	..
" Bonds, 7's	368,000	..	100	..
" " 6's	94,000	..	98	100
Metropolitan	870,000	100	200	..
" Bonds, 5's	70,000	..	..	..
Nassau	1,000,000	25	310	..
" Ctfs	700,000	1,000	99	100
Williamsburgh	1,000,000	50	310	..
" Bonds	1,000,000	..	107	110
Out-of-Town Companies.				
Bay State	5,000,000	50	19	25
" Income Bonds	2,000,000	1,000	..	30
Boston United Gas Co.—				
1st Series S. F. Trust	7,000,000	1,000	78	80
2d " " "	3,000,000	1,000	54	55
Buffalo Mutual	750,000	100	125	..
" Bonds	200,000	1,000	95	100
Central, San Francisco	2,000,000	..	95	..
Chicago Gas Co.	25,000,000	100	64⅝	64¾
Chicago Gas Lt. & Coke Co.				
Guaranteed Gold Bonds	7,650,000	1,000	94	94¼
Columbus	1,069,000	..	66½	67
1st Mortgage	1,085,000	..	94	95
Consumers, Jersey City	2,000,000	100	75	80
" Bonds	600,000	1,000	100	103½
Cincinnati G. & C. Co	7,000,000	100	203¾	..
Consumers, Toronto	1,600,000	50	184½	187
Capital, Sacramento	500,000	50	..	41
Bonds (6's)	150,000	..	..	..
Consolidated, Baltimore	11,000,000	100	57	59
Mortgage, 6's	3,600,000	..	107	107½
Chesapeake, 1st 6's	1,000,000	..	..	..
Equitable, 1st 6's	910,000	..	..	..
Consolidated, 1st 5's	1,490,000	..	..	..
Detroit	4,000,000	..	..	29
" Con. Bonds	4,312,000	..	71½	75
Equitable Gas & Fuel Co., Chicago, Bonds	2,000,000	1,000	..	101
Fort Wayne	2,000,000	..	72	75
" Bonds	2,000,000	..	84	87
Hartford	750,000	25	..	145
Indianapolis	2,000,000	..	..	145
" Bonds, 6's	2,650,000	..	100	104
Jersey City	750,000	20	180	..
Lafayette Gas Co., Ind	1,000,000	100	80	85
Bonds	1,000,000	1,000	85	88
Louisville	2,570,000	50	..	130
Laclede, St. Louis	7,500,000	100	18	19
Preferred	2,500,000	100	80	..
Bonds	9,084,400	1,000	98⅛	98⅝
Little Falls, N. Y.	50,000	100	..	100
Bonds	25,000	..	..	100
Montreal, Canada	2,000,000	100	200	..
Newark, N. J., Gas Co.	1,000,000	..	75	..
Bonds, 6's	4,000,000	..	120	..
New Haven	1,000,000	25	225	..
Oakland, Cal.	2,000,000	..	46½	..
" Bonds	750,000	..	..	..
Peoples Gas Lt. & Coke Co., Chicago, 1st Mortgage	2,100,000	1,000	..	108
2d "	2,500,000	1,000	104	105
Peoples, Jersey City	500,000	50	..	175
Paterson, N. J.	.....	25	90	102
Rochester Gas & Elec. Co.	2,150,000	50	..	..
Preferred	2,150,000	50	88	..
Consolidated 5's	2,000,000	..	87½	90
San Francisco, Cal.	10,000,000	100	71¼	72
St. Paul Gas Light Co.	1,500,000	100	68½	70
1st Mortgage, 6's	650,000	..	88	90
Extension, 6's	600,000	..	..	..
General Mortgage, 5's	2,400,000	..	88	90
Syracuse, N. Y.	500,000	25	..	..
Washington, D. C.	2,000,000	20	250	..
Western, Milwaukee	4,000,000	100	..	66
Bonds, 5's	3,556,000	..	85	88
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DIVIDEND NOTICE.

OFFICE OF THE UNITED GAS IMPROVEMENT CO., 813 DREXEL BUILDING, PHILA., Dec. 31, 1895.

The Directors have this day declared a quarterly dividend of 2 per cent. ($1 per share), payable in cash on Jan. 15, 1896, to stockholders of record at the close of business Jan. 10, 1896; also an extra dividend of fifteen (15) per cent. ($7.50 per share) payable in cash on the 3d day of March, 1896, without interest, to stockholders of record at the close of business Jan. 10, 1896. The right to participate in said extra dividend will be evidenced by the issue, on Jan. 15, 1896, of dividend scrip certificates to stockholders of record at the close of business Jan. 10, 1896. Said certificates will, at the option of the holder, if exercised on or before the 29th day of February, 1896, be convertible into the capital stock of the Company at par, when presented in sums of fifty dollars ($50) or multiples thereof. Checks and dividend scrip certificates will be mailed.

1074-2 EDWARD C. LEE, Treasurer.

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A Man to Take Full Charge of a Small Coal Gas Plant in Indiana.

Output, 5,000,000. Address

1075-1 "INDIANA," care this Journal.

WANTED,

A Competent Man as Engineer of a Gas Works.

Lowe process. Address, with references,

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Position Desired

As Supt. or Asst. Supt. of Coal or Water Gas Works

by a young man 28 years of age, willing to do anything around a coal or water gas works.

1073-3 Address "D. J.," care this Journal.

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Superintendent in charge of gas works making 17,000,000 cubic feet per annum desires change of locality. Has been with present company five years. Address

1072-tf "E. L. M.," care this Journal.

POSITION WANTED

As Supt. or Manager of a Gas Works or Gas and Electric Light Works.

Fifteen years' experience as Manager of Gas Works and six years Gas and Electric Light Works. Good reasons for wishing to change present employment.

1043-tf Address "Y. B.," care this Journal.

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A Second-Hand Gas Engine, from 3 to 5 Horse Power,

Address, giving make, size and condition,

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WANTED,

6½ x 6½ Ft. Station Meter,

8-inch Connections.

EAST RIVER GAS COMPANY,

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FOR SALE,

Gas Works,

in town of 10,000 inhabitants; all in first-class shape. For particulars write the Secretary,

GEO. A. KUHL,

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One No. 7 Gas Exhauster, Wilbraham-Baker Blower Company's Make.

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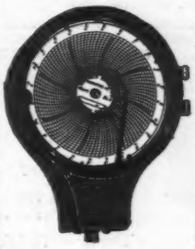

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Incandescent Light Burners with hardened head.....			18 cents each

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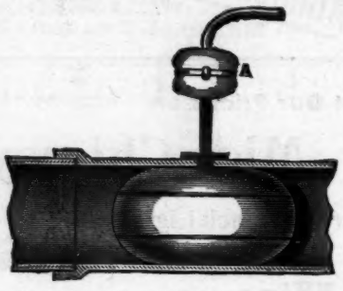

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5 " " "	1.05		20 " " "		12.00
6 " " "	1.75		24 " " "		17.00
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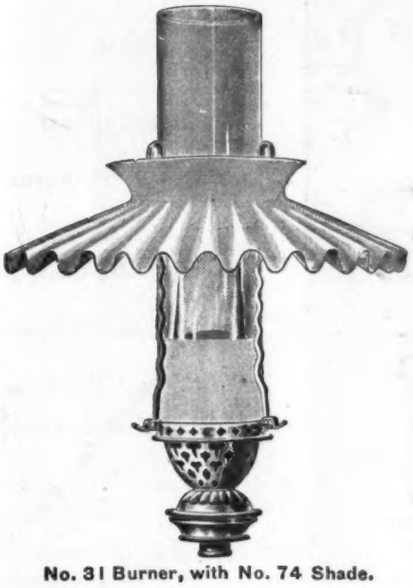

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Are the Cheapest, Most Economical and Most Durable in existence, and will, at their REDUCED PRICE, save their cost in gas alone in forty hours' use.

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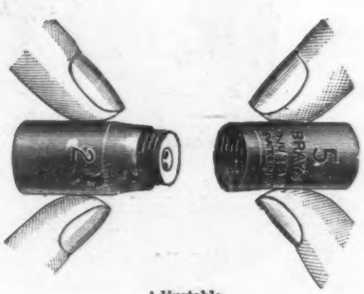
Slit Union.

Batswing.



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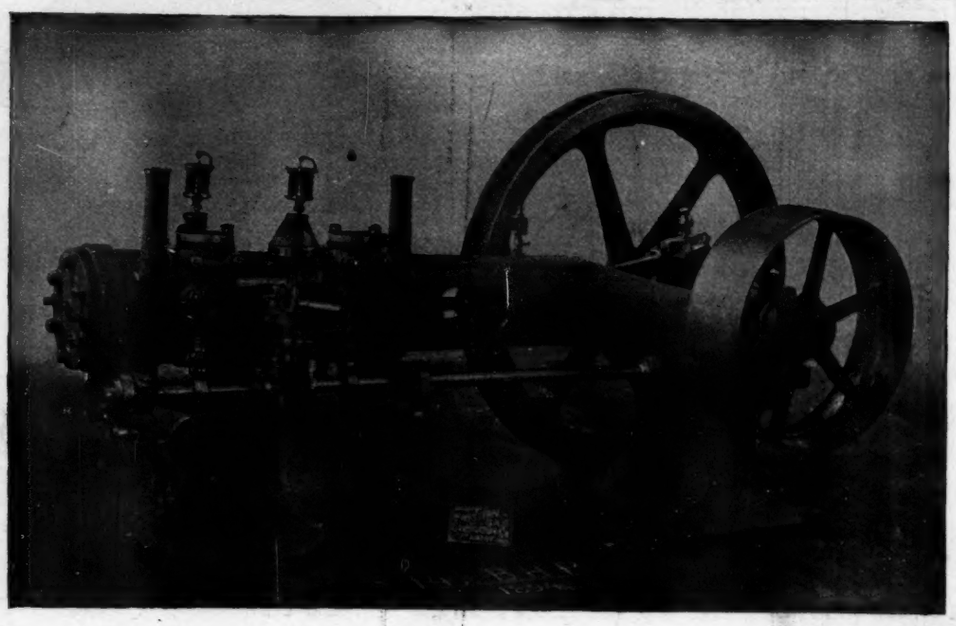

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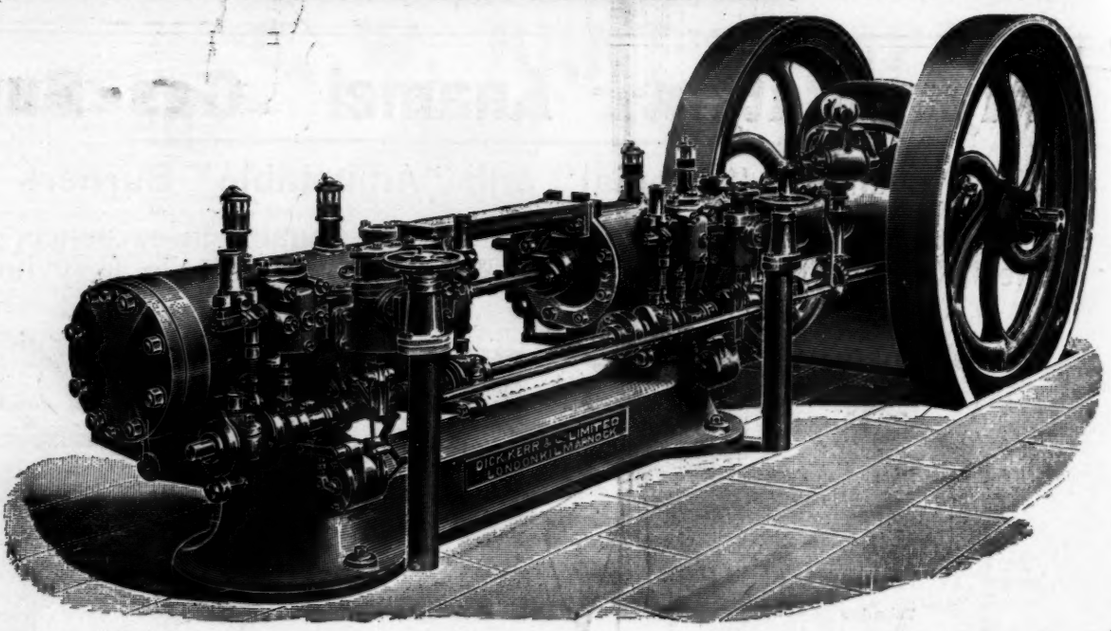

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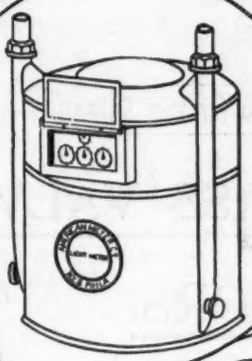

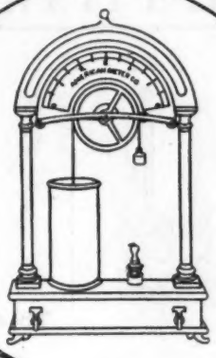

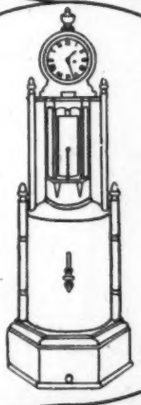

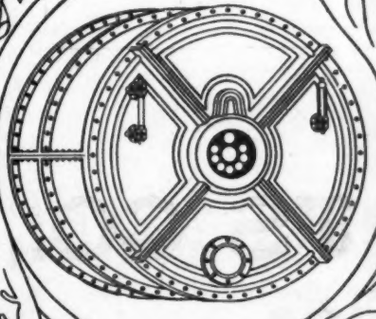

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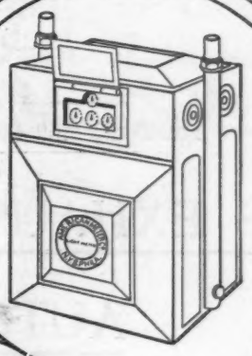
PUBLIC LIGHTING TABLE.

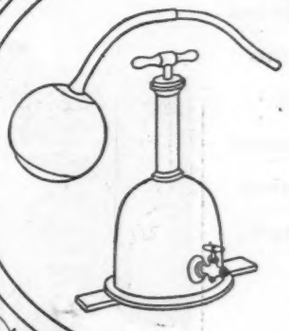
JANUARY, 1896.

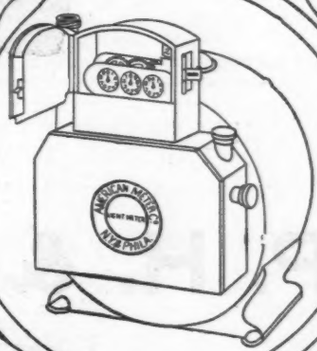
Day of Week.	Table No. 1. Following the Moon. Date.	Light.	Extinguish.	Table No. 2. New York City. All Night Lighting. Light.	Extinguish.
				P.M.	A.M.
Wed.	1	No L.	No L.	4.30	6.30
Thu.	2	5.20 PM	7.50 PM	4.30	6.30
Fri.	3	5 20	9.10	4.30	6.30
Sat.	4	5.20	10.30	4.30	6.30
Sun.	5	5.20	11.40	4.30	6.30
Mon.	6	5.20	12 50 AM	4.30	6.30
Tue.	7	5.20 LQ	2.10	4.30	6.30
Wed.	8	5.20	3.20	4.40	6.30
Thu.	9	5.20	4.30	4.40	6.30
Fri.	10	5.20	5.40	4.40	6.30
Sat.	11	5.20	6.20	4.40	6.30
Sun.	12	5.30	6.20	4.40	6.30
Mon.	13	5.30	6.20	4.40	6.30
Tue.	14	5.30 NM	6.20	4.40	6.30
Wed.	15	5.30	6.20	4.50	6.25
Thu.	16	5.30	6.20	4.50	6.25
Fri.	17	5.30	6.20	4.50	6.25
Sat.	18	5.30	6.20	4.50	6.25
Sun.	19	8.50	6.20	4.50	6.25
Mon.	20	9.50	6.20	4.50	6.25
Tue.	21	10.50	6.20	4.50	6.25
Wed.	22	11.50 FQ	6.20	5.00	6.25
Thu.	23	1.00 AM	6.20	5.00	6.25
Fri.	24	2.00	6.20	5.00	6.25
Sat.	25	3.10	6.20	5.00	6.25
Sun.	26	4.10	6.10	5.00	6.25
Mon.	27	5.10	6.10	5.00	6.25
Tue.	28	No L.	No L.	5.00	6.25
Wed.	29	No L. FM	No L.	5.05	6.15
Thu.	30	No L.	No L.	5.05	6.15
Fri.	31	5.50 PM	8.10 PM	5.05	6.15

TOTAL HOURS LIGHTING DURING 1896.

By Table No. 1.	Hrs. Min	By Table No. 2.	Hrs. Min.
January	220.40	January	423.20
February	207.00	February	367 40
March	193.00	March	355.35
April	174.10	April	298.50
May	164.00	May	264.50
June	142.10	June	234.25
July	142 10	July	243.45
August	150.50	August	280.25
September	163.00	September	321.15
October	193.10	October	374.30
November	207.00	November	401.40
December	237.30	December	433.45
Total, yr.	2194.40	Total, yr.	4000.00







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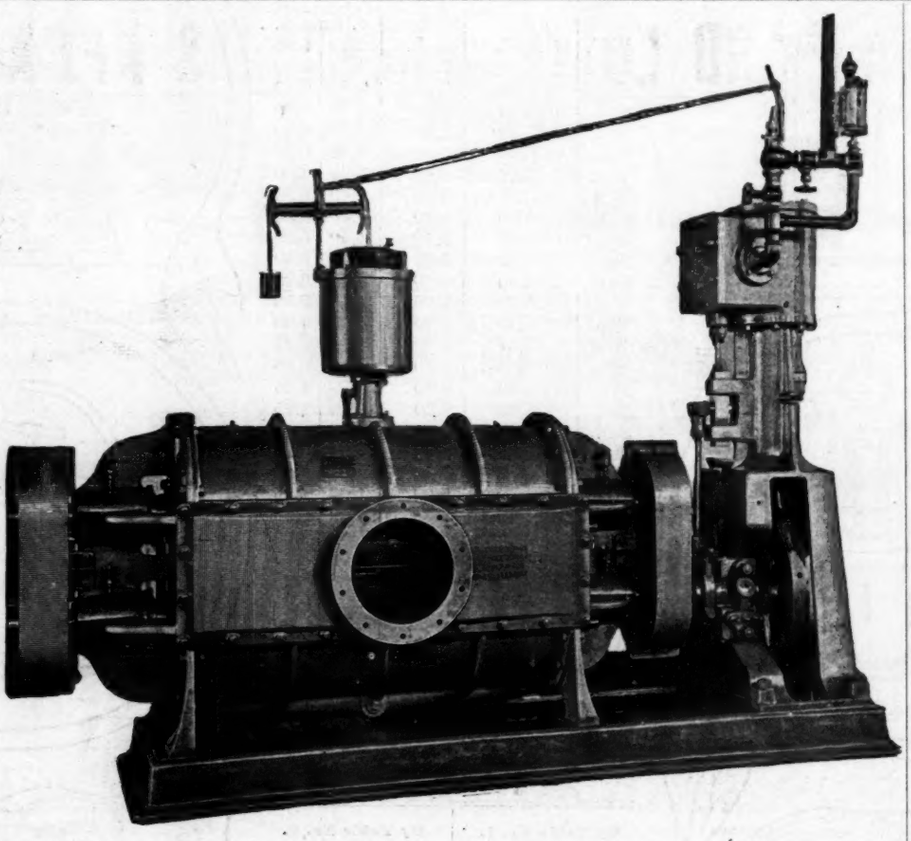

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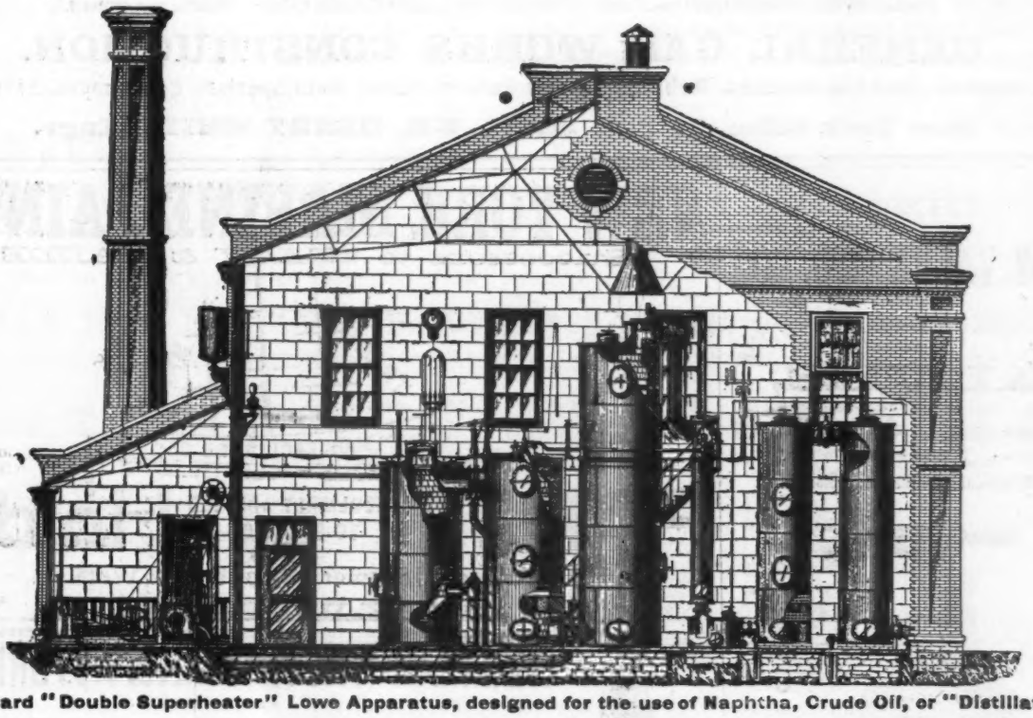

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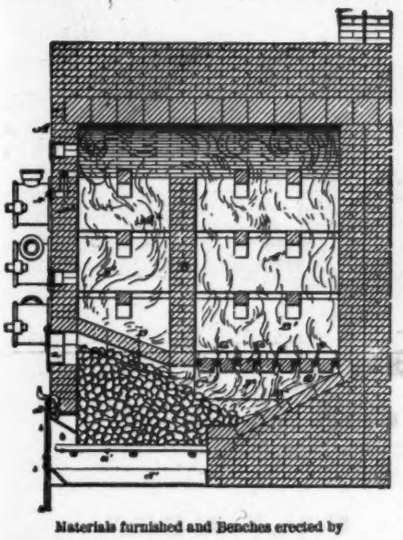

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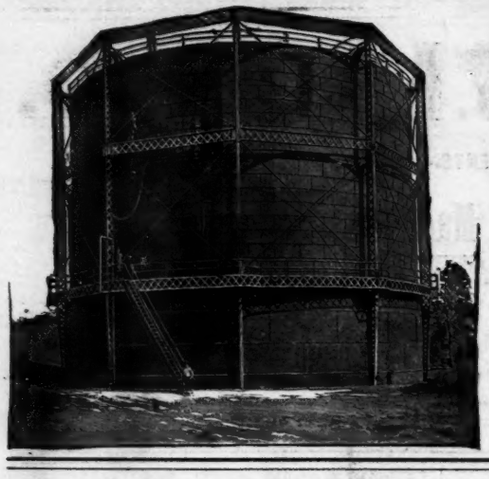

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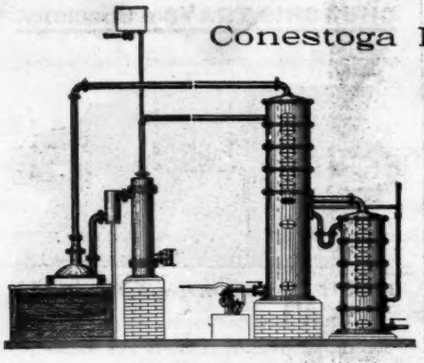

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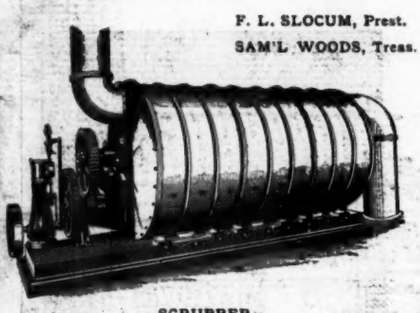

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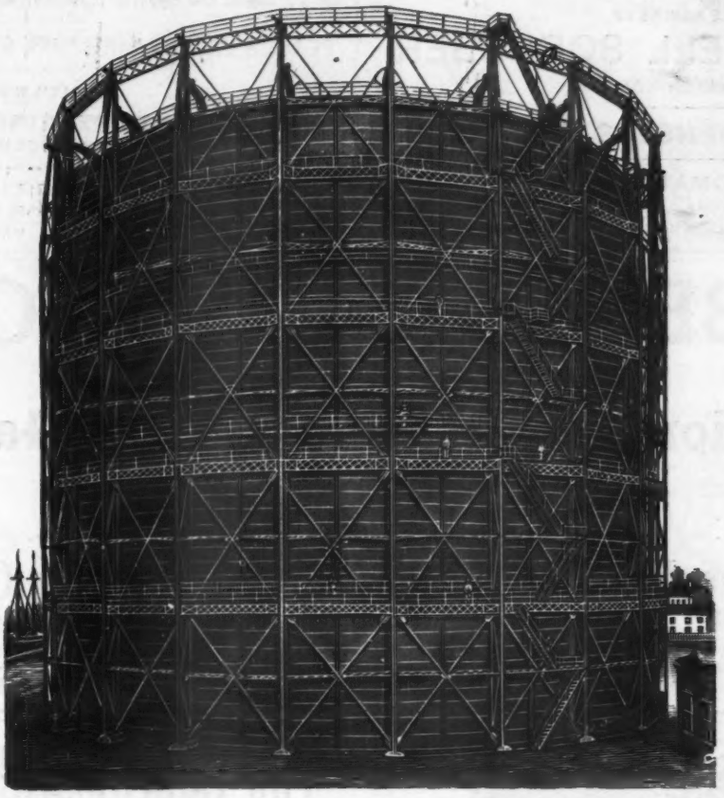

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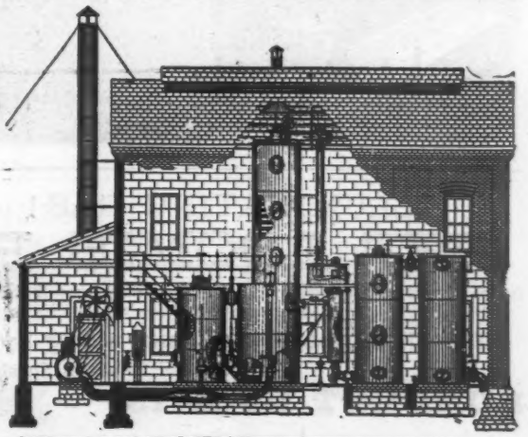

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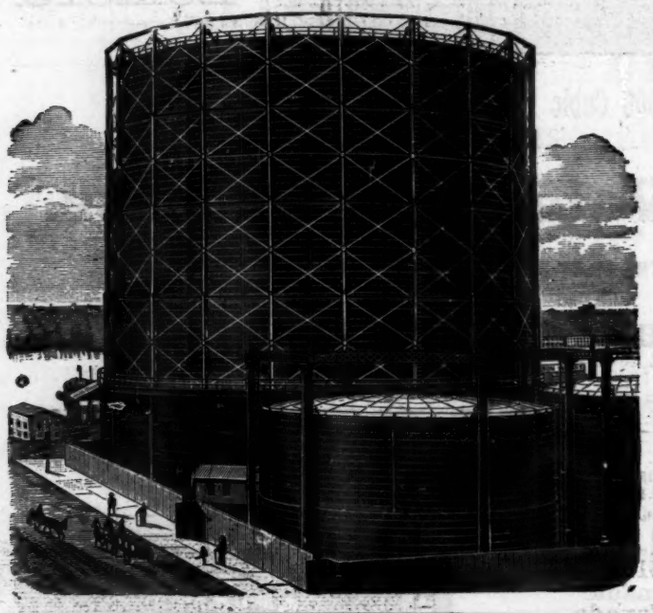

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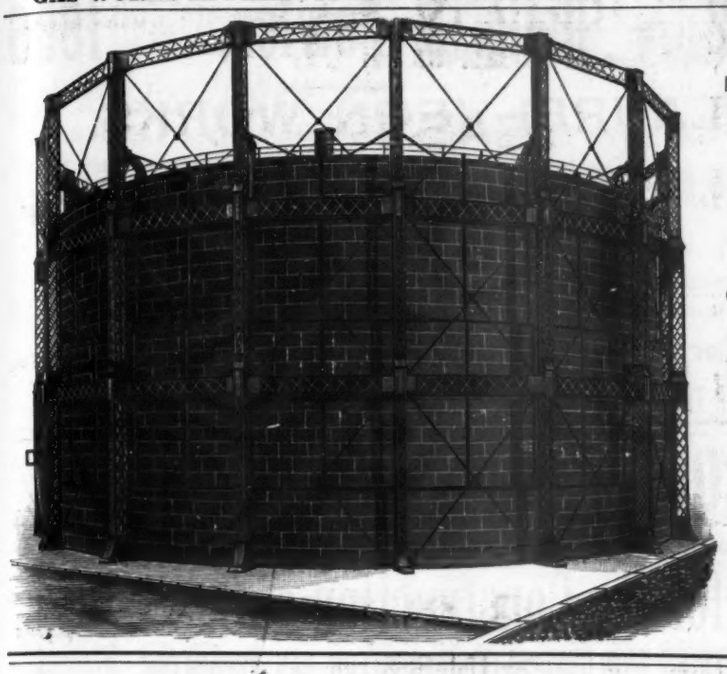

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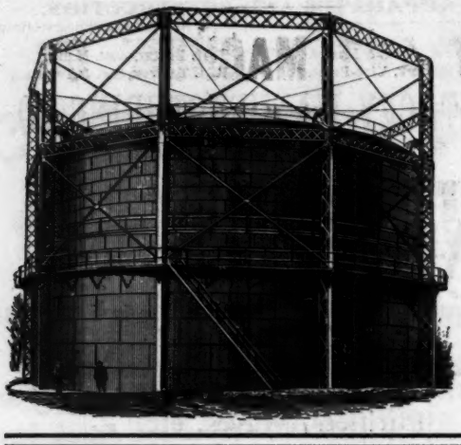

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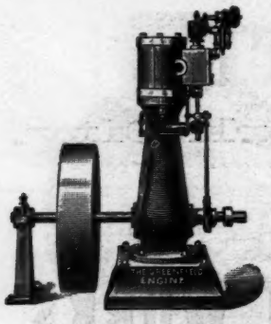

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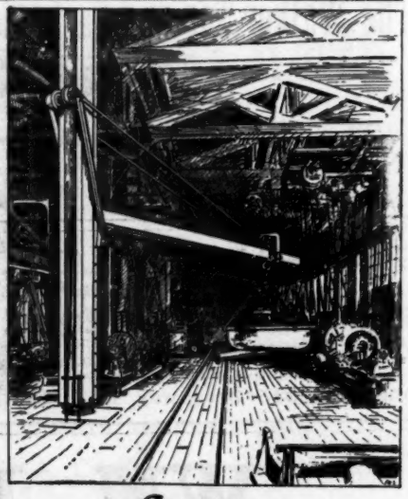

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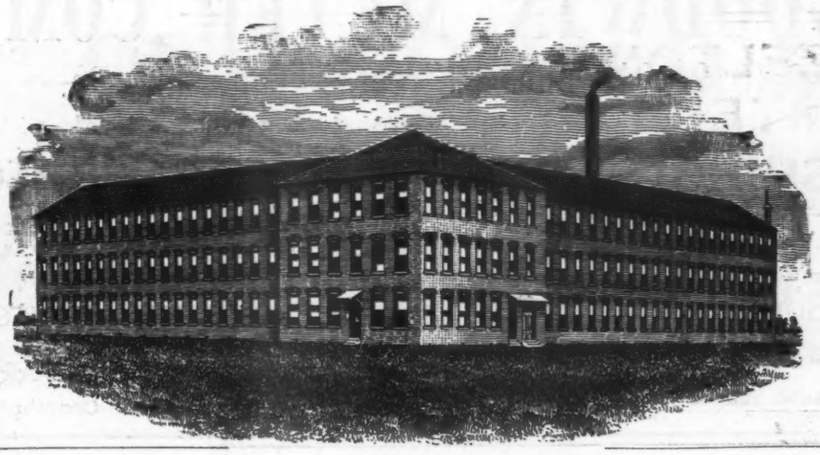

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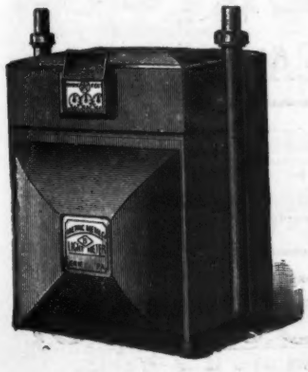

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